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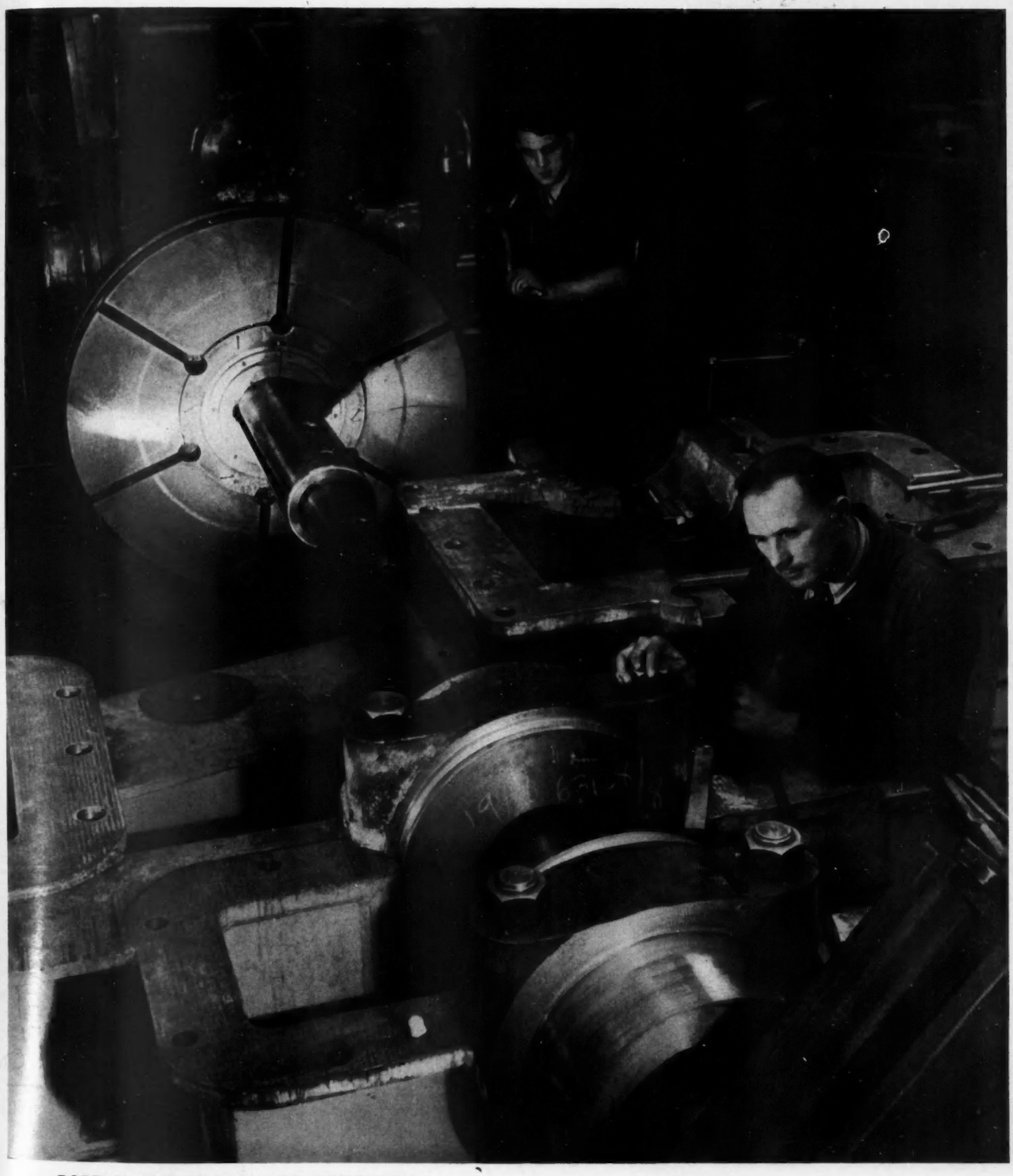

BORING A BLOOMING-MILL DRIVE BOX

# The stations marked ✓ are equipped with Lockheed hydraulic remote control equipment

| POWER STATION | B.E.A. DIVISION | BOILER PLANT BY |
|---|---|---|
| ✓ Bankside | London | Foster-Wheeler |
| ✓ Barking 'C' | London | Babcock and Wilcox |
| ✓ Battersea 'B' | London | Babcock and Wilcox |
| ✓ Bold 'A' | Merseyside and North Wales | Yarrow |
| ✓ Braehead | South West Scotland | Babcock and Wilcox |
| ✓ Brighton 'B' | South Eastern | Babcock and Wilcox |
| ✓ Bromborough | Merseyside and North Wales | Babcock and Wilcox |
| Brunswick Wharf | London | Clarke Chapman |
| ✓ Carmarthen Bay | South Wales | Babcock and Wilcox |
| ✓ Carrington | North Western | Babcock and Wilcox |
| ✓ Chadderton | North Western | Simon-Carves |
| ✓ Clarence Dock | Merseyside and North Wales | — |
| ✓ Connah's Quay | Merseyside and North Wales | International Comb. |
| ✓ Croydon 'B' | South Eastern | Simon-Carves |
| Deptford East | London | Foster-Wheeler |
| Doncaster | Yorkshire | Mitchell |
| East Yelland | South Western | John Thompson |
| Huddersfield | Yorkshire | Bennis |
| ✓ Huncoat | North Western | Simon-Carves |
| Keadby | Yorkshire | Stirling Boiler Co. |
| ✓ Littlebrook 'C' | South Eastern | International Comb. |
| Nechells 'B' | Midlands | International Comb. |
| ✓ North Tees 'C' | North Eastern | Babcock and Wilcox |
| ✓ Poole | Southern | International Comb. |
| ✓ Roosecote | North Western | Yarrow |
| Rotherham | Yorkshire | International Comb. |
| ✓ Rye House | Eastern | Babcock and Wilcox |
| ✓ Skelton Grange | Yorkshire | International Comb. |
| ✓ Staythorpe | East Midlands | Babcock and Wilcox |
| Thornhill | Yorkshire | International Comb. |
| ✓ Uskmouth | South Wales | Babcock and Wilcox |
| ✓ Walsall | Midlands | Mitchell |
| ✓ West Ham | London | Babcock and Wilcox |
| Westwood | North Western | Babcock and Wilcox |
| | | John Thompson |
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## INDUSTRIAL HYDRAULICS

AUTOMOTIVE PRODUCTS COMPANY LIMITED LEAMINGTON SPA ENGLAND

# ENGINEERING

An Illustrated Weekly Journal

Vol. 180 No. 4673 AUGUST 19, 1955



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## REACHING THE UPPER ATMOSPHERE

ALTHOUGH the artificial satellite was proposed as early as 1897 in a fictional work by a German professor of mathematics, Kurd Lasswitz, it was not until the 1930's that its inherent usefulness was recognised. Hermann Oberth, the "father of astronautics," now working in the United States with von Braun the former German V.2 chief, suggested the use of space stations in his first book published in 1923. He visualised large man-carrying stations devoted to research work, their use for refuelling space-ships being considered as of only secondary importance.

All of these projects involved man-carrying vehicles and assumed the need to return the pilot in his cabin intact to earth. Sometimes this was to be done by destroying the vehicle's kinetic energy by braking rockets, sometimes by parachutes and, more recently, by gliding techniques. But the first simple step into space, that of putting a small satellite containing a few instruments into an orbit a few hundred miles high has been seriously advanced only during the past decade. The reason for this apparent oversight is that until the end of the Second World War reliable automatic control, telemetering equipment, lightweight power supplies and miniature electronic components just did not exist. A small artificial satellite without these items, whilst not being completely useless, could never have justified the tremendous expenditure that it would have involved.

Since the last war the various American agencies have spent many millions of pounds on rockets for upper-atmosphere research. Some of these have been modified military missiles; others have been designed and built specifically for research purposes. One of the most recent of these, the Viking, was designed for investigation in the regions in which it is now intended to put artificial satellites and it is of interest to examine the economics of the Viking and the satellites.

The Viking is capable of carrying a 120-lb. payload to nearly 200 miles altitude. In common with all other vertical-ascent sounding rockets it has the major drawback that it is in the regions of interest for a very short time, whereas the main advantage of the proposed satellite is that it will permit continuous data-collection at a fairly constant altitude over very long periods. The useful time of the Viking's flight is unlikely to exceed six minutes. For such a short time the weight of the power supply would be negligible and thus the whole of the 120 lb. payload can be assumed to be instruments. A conservative figure for the cost of manufacture and firing of a Viking is £100,000. Thus the cost per pound of equipment per minute of useful recording time is about £140.

The announced cost of the satellite project of £3½ million can only be to render existing rockets suitable for the work in mind. It seems probable that the satellite, weighing perhaps 150 lb. and with a diameter of about 18 in., would be placed in the nose of an Aerobee sounding rocket which, in turn, would be in the nose of a Redstone missile. Undoubtedly both these must be lightened for this project and it is likely that a propulsion unit will be needed in the satellite itself; this could well be a series of small solid-propellant rocket motors. A figure of 50 lb. for the useful payload seems reasonable and if this were divided equally between power supply (assuming the use of lightweight secondary cells) and instruments, the useful life of the satellite would be about 50 hours. At 200 miles altitude the satellite would not in fact return to earth for about 25 days. If only one satellite were placed in an orbit the cost per pound of payload per minute of operation would amount only to about £50. In practice it is unlikely that only one vehicle will be fired and the relative cost could easily be an order of magnitude less than that of a comparable programme of Viking firings.

The provision of a reliable lightweight power supply has previously been difficult. But during the past few years various agencies have developed silicon-boron photocells, the best of which can produce 50 watts per square yard of exposed surface, although only about 25 watts would be needed. The relative cost per pound-minute would then be reduced to a very low figure.

The first satellites will extend the fields already under investigation using high-altitude rockets. These are ionospheric and auroral physics, solar radiation, cosmic radiation and geodesy. One other field of study certain to be greatly advanced is meteorology.

It is not to be visualised that these satellites could ever be permanent. Residual air drag—even in regions of high vacuum—will eventually slow the satellite and bring it back to earth. At heights of 30 to 50 miles compression heating will enable temperature measurements to be made that will prove invaluable in the design of winged returnable satellites.

The next steps of man-carrying satellites, then of true space-ships, will not come immediately on the heels of this new project. Given the first satellites only two years hence, however, man might be forgiven for accepting the suggestion that one of his kind will land on the moon before the end of the century.

# Weekly Survey

**Cover Picture:** *One stage in the construction of a 42-in blooming mill is illustrated by our cover picture this week. The particular operation shown is that of boring the manipulator drive box.*

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## STEEL PIPING UP

A bright future for the European steel pipe and tube industry is forecast by the Economic Commission for Europe in a report, *The European Steel Pipe and Tube Industry*, prepared by the Industry Division and published by the United Nations. The authors visualise an increase of over one million tons in European output in five years, to a total of 5·1 million tons in 1960, though demand in Western Europe " may easily be substantially in excess " of this estimate.

The report reaches these optimistic conclusions after a detailed examination of the growth and development of the industry, its organisation and the trends of production and consumption. It notes that, so far, in most countries, the consumption of steel tubes during the past 15 years has grown faster than that of crude steel except in the U.K., where " tubes have tended to lag behind steel, partly perhaps owing to the influence on the latter of the rapid development of flat products." They consider that the economic development of the less industrialised countries of the world should lead to a considerable demand for tubes for use as common carriers for conveying water and liquid or gaseous fuels. The growth of the main tube consuming industries in the past few years has been at a much higher rate than industrial production generally and there is much to suggest that this can be expected to continue. These industries include petroleum, natural and manufactured gas, building construction and the manufacture of motor vehicles, machinery and ships—all of which have either large expansion programmes or very full order books.

Price trends and competition are discussed. Lack of precise information on costs and profits has prevented an assessment of how far tube prices have been kept unduly high in the post-war period by the high degree of concentration in the industry, particularly in Europe. The main conclusions are that prices have tended to rise less than crude steel prices and that the main hope for price reductions lies in greater standardisation: the report states that to some extent " the customer himself has been responsible for keeping the costs of tubes higher than they need be, by the multiplicity of sizes and wall thicknesses which he has grown into the habit of demanding."

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## INDUSTRIAL BUILDING INCREASES

More factory building was authorised during the first half of this year than during any six months since the war, and four-fifths more than during the first half of 1954. The Board of Trade's figures, published last week, show that plans for 29·5 million sq. ft. of new industrial buildings were approved between April and June—25 per cent. more than in the first quarter of the year and over 65 per cent. more than the quarterly average in 1954.

This is clear-cut evidence that the attempt the Government made a year ago to stimulate investment in manufacturing industry has succeeded. Early in 1954 the licence-free limit on building was raised to £25,000; that year's budget introduced investment allowances and in November building licences were abolished. Current statistics are only beginning to reflect the effect of these relaxations and incentives on manufacturers' plans. It remains to be seen what impact the Government's dearer money and credit restriction policies will have on the implementation of the plans. Some wastage normally takes place during the time-lag between the granting of an I.D.C. and the commencement of construction (12 to 18 months) and a good many of the schemes are likely to fall through, particularly those of the smaller businesses which depend on credit more than the larger firms and which will now find the money hard to get. Leaders in " growth " industries, on the other hand, such as steel, motor vehicles, mechanical handling, instruments, etc., tend to base their plans for expansion on their own long-term estimates of demand and are therefore unlikely to be affected.

Statistics for industrial building approved from June, 1945, to the end of 1954 show that over two-thirds of the 16,000-odd schemes were for buildings of less than 20,000 sq. ft. and these accounted for 28 per cent. of the total floor area. This compares with 38 per cent. accounted for by schemes of 100,000 sq. ft. or more, which constituted only 3½ per cent. of the total number. Leaders in the post-war expansion are the engineering, shipbuilding and electrical-goods industries with about 20 per cent. of the total floor space, followed by the chemical industry with 13 per cent. and the motor vehicle industry with 11½ per cent. Altogether, metal and engineering industries accounted for over 47 per cent. of the total floor area, 2 per cent. less than their share of the manufacturing labour force. If news of expansion schemes is anything to go by, engineering and metals, particularly vehicles, are likely to account for well over half the total floor area of schemes approved so far this year.

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## WORLD DEMAND FOR AIRLINERS

Some estimates of world demand for civil airliners were given by Mr. Peter Masefield, chief executive of British European Airways, when he addressed the U.S. Institute of Aeronautical Sciences in Seattle recently. According to Mr. Masefield, major equipment requirements in world civil air transport operation in the nine years 1958 to 1966 will amount to 2,700 air liners, costing, with spares, more than £2,500 million and requiring an output of about 1,800 jet engines and 13,400 turbo-prop engines. He called the period under review " the era of the turbine-transport."

The estimates are divided into seven categories of aircraft now being developed. The first, a transatlantic jet liner carrying over 100 passengers at speeds of 550 m.p.h., would number about 200 aircraft costing some 1,500 million dols. The only two contenders for this market appear to be the Douglas DC-8 and the Boeing 707. The second category, a long-range propeller-turbine aircraft for similar duties at lower speeds, such as the Britannia, would involve about 400 aircraft costing also about 1,500 million dols. Third would be the medium jet aircraft such as the Comet IV, requirements being about 100 at a cost of 300 million dols. Medium range turbo-propeller aircraft, such as the Viscount Successor and the Lockheed Electra, would constitute a fourth large category of about 400 aircraft costing 1,500 million dols. Fifth would come the second-string, " work-horse " type for medium and short hauls; the Viscount Major (V 800 series with higher-powered Rolls-Royce Dart engines) is the chief contender for the 400-odd aircraft needed. Sixth, replacements for Douglas DC-3, demand being estimated at about 600 of a small, cheap four-engine plane each costing with spares less than 600,000 dols. The seventh and last category consists of large multi-engined helicopters for use between city centres up to 250 miles apart, each costing not much more than 200,000 dols. Demand for these, " if such a helicopter could be built," was estimated at 500 or more during the nine-year period under review.

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## BUYING AIRLINERS

B.O.A.C. do not much like being guinea pigs for the aircraft industry, having to buy airliners " off the drawing board " nearly seven years before they will carry their first passenger; they do not like the fanfare of publicity that greets every development in British aircraft design; they would dearly like to see less accent on prototypes and more of the production of saleable articles as well as fewer delays in delivery schedules. The British aircraft industry leads with the Viscount in the short-range aircraft market, and the Britannia promises well in the market for long-range aircraft but the British supremacy in long-range jet airliners is in danger. The expenditure by the Douglas Company of America of 100 million dols. in the development of the jet-propelled DC8 is a serious challenge to the Comet IV which is due to fly in 1959. These are the main impressions derived from a spirited article giving the airline operator's point of view, by Sir Miles Thomas, chairman of B.O.A.C., published in the *Financial Times* of August 8. He writes " We in B.O.A.C. have a dual duty—to keep our operations financially profitable and to promote British aircraft." It is of these basic functions, so often conflicting, that Sir Miles writes with intimate knowledge and refreshing good sense, even if one discerns impatience from time to time with some aspects of the organisation and operation of our aircraft industry.

The current cost of an international airliner is between £1 million and £1½ million, and a minimum fleet of 10 is needed " for competitive economy of operation." The modern long-range airliner takes seven years at least between " freezing an agreed specification and delivery into airline service." The original order for Britannias was placed in 1949 and B.O.A.C. hope to have them in service in April next year, having already paid £20 million in progress payments to the makers. Modifications are a curse to factories but " the speed of design development in aircraft to-day outstrips the pace of prototype building and line production." The need to remain competitive on the Atlantic route forced B.O.A.C. to buy the Douglas Seven Seas " to plug the gap " until the Britannia 300 LR is ready.

These are some of the facts in a most interesting and stimulating statement. Sir Miles' suggestion that an annual air display (Farnborough) is out of place for an industry whose products take seven years " from conception to adolescence," and his pleas for " fewer circuses, lectures, banquets, displays and speeches," should find a wide audience within the industry itself, and among the operators as well as the general public who foot the bill.

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## HOME-MADE MACHINE TOOLS

The growth of mass production and specialisation has led in recent years to the practice of firms making their own machine tools; a revival from the days when Henry Maudslay first developed the metal-turning lathe for his engineer employers. This development has been accelerated recently by the increasing complication and cost of general-purpose machine tools and the growing number of machining operations in industry which have to be repeated for hours on end on the same component without change of cutting tools, speeds or feeds.

An advanced example of this development is the design by the Austin Motor Company of its own transfer machines for cylinder blocks and other engine and transmission components. A complete range of standard machining heads, tables, columns and transfer mechanisms has been designed and put out to sub-contractors to manufacture. In this way the planning engineer's job is simplified and the cost reduced

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In the note " American Shipping and Shipbuilding," last week, it was reported that American shipping lines were likely to be spending over £1 million in the next few years on modernisation and expansion of their fleets. The figure should have been £1,000 million.

below that which would have been incurred for individual machines. It has even been found economic to supply such machines to the Australian company for its comparatively limited market.

The development of standard drill heads and the adaptation of portable electric and pneumatic drills, as well as the availability of a standard range of hydraulic link motions, have all contributed to the ease and economy of design of machine tools for special application. Electronic control of speed can readily be incorporated and developments in full electronic control are likely to take this process still further.

Specialised equipment has the main advantage of speeding up the machining process and so reducing direct labour costs. It may also assist in the reduction of overheads by reducing the floor-space needed and the power consumed. In the past the capital costs of such developments have usually been very high and they have only been profitable when associated with very great increases in output. If the development of standard components for building specialised machine tools can result in substantial savings in capital costs, even for the same output, then there are new opportunities for the machine tool industry. From the point of view of the national economy, anything which will reduce the costs of expanding and re-equipping our industries is to be welcomed.

* * *

## RISING COSTS AND FOREIGN COMPETITION

To see costs rising steeply without being able to raise prices is a galling experience for the manufacturer of engineering products who is conscious of his very responsible position in the country's economy. Engineering products, in the manufacture of which nearly half this country's manufacturing labour force is engaged, are Britain's main hope in avoiding bankruptcy as well as in the maintenance of a rising standard of living. But there exist in Europe and America engineering industries able to operate at lower costs than ours, or Governments willing to subsidise engineering exports. The position is difficult, and could quickly become critical (new claims for increased wages are discussed in the Labour Notes of this issue).

The chairman of Edgar Allen and Company, Limited, Mr. W. H. Higginbotham, focused attention on rising manufacturing costs in his recent statement to shareholders. He points out that " It has not been possible to recoup more than a portion of these increases by raising selling prices . . . In certain cases there have actually been substantial price reductions." The fall in the Edgar Allen Group's export business during the year under review (to April, 1955), even where they operate local companies, as in Canada and South Africa, is disturbing. The Canadian company made a small loss, and, according to the chairman " can make, at any time, little or no local profit " since it sells in Canada the parent company's products imported at U.K. prices plus freight and import duties.

The Group report a marked growth in the relative importance of their engineering and trackwork products in relation to steel, tools and magnets and steel castings. The engineering and trackwork products increased their contributions to total turnover to 32·4 per cent. (4 per cent. increase), and that to total profits to 42·6 per cent. (an increase of nearly 10 per cent.). Steels, tools and magnets accounted for 34·2 per cent. of turnover and steel castings for 29·4 per cent. The chairman said that additions to fixed assets during the year totalled over £250,000, singling out the powdered metals division for special mention. The acquisition of J. H. Humphreys and Sons, of Oldham, makers of electro-magnetic chucks, carries further the diversification of the group's products which, as Mr. Higginbotham points out, " tends to stabilise the over-all earnings of the Company."

## AN EXPANDING COMPANY

News of expansion and considerable additions to plant and machinery was given by Mr. G. E. Liardet, Chairman and Managing Director of Simms Motor Units Limited, in his annual statement to shareholders published recently. The company, who manufacture fuel-injection, lighting, starting and ignition equipment for the motor and aircraft industries and for Diesel-engine manufacturers, have substantially increased the effective floor area of their existing buildings and have completed their plans for the erection of a large modern factory on land belonging to their subsidiary company, Horstman Limited of Bath. Simms have a technical association with the American Bosch Corporation of Springfield, Mass., and have made several prototypes of the Bosch distributor pump which are at present undergoing field tests. Mr. Liardet said his company were doing research and development work on fuel-injection and electrical apparatus to meet the requirements of the small high speed Diesel engine, which is a logical development of the present world trend in oil-engine design—a development which has been held back by the lack of suitable accessories.

Mr. Liardet took the opportunity to deny rumours that there had been take-over bids for his company. He said that they had improved their position and increased their profits for the year under review and that they had received much encouragement and support from some of their larger customers in what the chairman described as " our fight to maintain competition in the supply of certain most vital components for the commercial vehicle industry."

* * *

## INFLATION IN AUSTRALIA

Recent developments in Australia are not encouraging. They suggest that the country is in the midst of acute inflation with consequential labour troubles, as well as in serious difficulties over its balance of payments position. During July the Commonwealth Bank's holdings of gold and foreign exchange fell by £A20 million, to £A355 million at the end of the month. They were then almost £A200 million below the level at which they stood when an adverse balance began to develop on the country's external trade in the second quarter of last year. To some extent the deterioration in the position that took place in July may have been due to the dock strikes in this country and in Australia which affected imports more than exports in May and June with a consequent surge in imports when they ended. Another factor is the seasonal drop in the country's income from wool sales. Recent drawings on reserves, however, have been very heavy and unless this trend is reversed during the next month or two the Australian Government may be forced to impose import quota restrictions far more drastic than those imposed last September. Surprisingly enough, the latter appear to have had little effect on the total value of shipments from this country to Australia: during the first half of the year they were actually £3 million greater, at £140 million, than in the corresponding period of 1954.

Meanwhile, rising prices have led to widespread industrial unrest. So far, there has been no attempt to start nation-wide strikes but there is much dissatisfaction with wage levels, which were frozen by a decision of the Federal Arbitration Court in September, 1953, while price controls were removed. These have been reintroduced in several States but probably too late to stem the tide. Any relief to wage earners in such circumstances would add to inflationary pressures, but the absence of relief will almost certainly touch off a new wave of strikes. The recent grant of pay increases to skilled workers, whose claims were backed by the Federal Government, has added fuel to the flames. From the point of view of British exporters, the situation is delicate and requires watching carefully.

## MARKETS FOR NUCLEAR ENGINEERING

What has clearly emerged so far from the Geneva Conference on the Peaceful Uses of Atomic Energy is that electricity can be generated from nuclear fuels at costs competitive—or soon likely to become so—with traditional fuels. This is particularly true, as in the United Kingdom, where the costs of extracting fossil fuels are relatively high. Even where they are abundant, according to Professor Blokhintsev of Russia, the overall cost of electricity generated at an improved nuclear station " will not be much more than the cost at a good coal-fired station." The symposium on uranium and thorium established beyond doubt that the world's supplies of nuclear fuels are ample. Developments in the design of reactors are likely to reduce fuel consumption and if fusion reactions can be used—perhaps within two decades—the world will cease to have fuel supply problems.

The commercial implications of these developments are clear enough: the industrialisation of countries with poor resources of coal, oil or natural gas will become possible on a competitive basis; and the world's traditional fuel industries will find, within 15 to 20 years, that there will be a fall in the demand for their products in such fields as electrical power generation and other applications where electricity is already employed. However, the expansion of world industry will probably more than offset this by raising the demand by other users, such as steel making and transport. Finally, a world-wide demand will arise for nuclear generating plant and ancillary equipment, such as electronic instruments.

Another fact brought to light by the conference and the associated fair is the vast lead held by this country, the U.S. and the U.S.S.R. over other industrialised nations, a result of their having developed, under the pressure of military necessity and irrespective of cost, the necessary basic plant. This includes the equipment needed for the enrichment of natural uranium, and the initial reactor, which cost between £35 million and £50 million. Yet few will take seriously the suggestion that these three countries will keep their monopoly, though for some years they will remain the only producers of atomic fuels. Other industrialised countries which already make high-quality large-capacity boilers and turbo-generators will in time join them in supplying world needs. In the intervening years there is a golden opportunity for the United Kingdom to consolidate the lead it has already gained and build up a valuable export trade.

* * *

## ATOMIC GLOSSARY

In this issue we continue our report on the International Conference on the Peaceful Uses of Atomic Energy at Geneva, and as a guide for the non-specialist we are publishing on page 255 a glossary of terms encountered in this field.

The articles on the Conference appearing this week include an abridged version of the Presidential Address by Dr. Homi J. Bhabha (page 234); and a description of the first atomic power station in the U.S.S.R. (page 233)—this report, besides being of interest as an indication of current atomic progress in the Soviet Union, serves, too, as an introduction to the nuclear reactor and its associated problems. A summary of a United States boiling-water reactor is also given, together with an account of the discussions which followed both the Russian and American papers (page 228). A British high-flux research reactor, the E.443 (Dido) is described on page 235, and on page 232 we publish a brief survey of the United States nuclear-reactor programme.

In previous issues have appeared our first article on the British industrial exhibits at Geneva (August 5, page 176), and an abridged paper surveying the economics of future nuclear developments, applying specially to Canada but serving, too, as an indication of prospects in other industrial countries (August 12, page 198).

# TWO SMALL POWER REACTORS

## EXPERIMENTAL ATOMIC ENERGY PLANTS IN THE U.S.S.R. AND UNITED STATES

*The Soviet Union and the United States have both successfully operated small power reactors, and a description of the Russian station extracted from a paper* on the subject delivered at the International Conference on the Peaceful Uses of Atomic Energy appears on page 233 in this issue. We give here some further comments by Professor D. I. Blokhintsev on the installation, together with a summary of the discussion which followed the reading of the paper. During the same session (morning of Tuesday, August 9), Dr. W. H. Zinn presented a paper prepared by himself and others at the Argonne National Laboratory, U.S.A., on a boiling-water reactor and power plant. A summary of this paper and the ensuing discussion is also included in this article.*

### SOVIET 5-MW PLANT

The 5,000-kW Soviet plant employs a graphite-moderated enriched-uranium fuelled reactor to heat water that is maintained under pressure to prevent boiling. This water carries heat produced in the reactor to a heat exchanger in which water in a secondary circuit is boiled to form steam. This steam operates a turbo-generator.

Professor Blokhintsev observed that costs were higher than in larger conventional power plants but were competitive with conventional plants of the same size. The present high cost was due partially to the need to fabricate fuel elements only in small quantities, and also to the fact that slightly enriched uranium (5 atoms of uranium 235 per 100) must be used. With larger reactors a substantial drop in costs was expected; enrichment could be reduced and uranium 238 could be converted in greater quantities to fissile plutonium, so providing a valuable by-product. Future plants would not necessarily follow the pattern set by the first; water-moderated and cooled reactors appeared to be particularly attractive.

Opening the discussion, Dr. W. B. Lewis of Atomic Energy of Canada, Limited, remarked that the Russian reactor was similar to the Canadian NRX research reactor in that it had many instruments for measuring the operating parameters. The measurements were used in controlling the reactor and Canadian experience had shown that numerous shut-downs arising from faulty instrument operation occurred. Professor Blokhintsev replied that during the first two months there had been numerous shut-downs for this reason but subsequently no case of shut-down due to instrument defects or misoperation had arisen.

### BREEDING AND CONVERSION RATIO

Dr. W. F. Libby of the United States Atomic Energy Commission observed that, whereas most of the American power-reactor programme (summarised on page 232) was based on installations with high conversion ratios (the ratio between the quantity of fissile material produced and the amount consumed in the chain reaction), the Soviet reactor had a low conversion ratio. He asked if conversion ratios near unity (same quantity produced as consumed; in a " breeder " reactor the conversion ratio exceeds unity) were planned for large plants, and in addition how fuel elements would be changed.

In answer, Professor Blokhintsev stated that both the lattice (fuel arrangement) and materials would be different in larger reactors. Zirconium alloys, for example, would be used to decrease the absorption of neutrons by structural materials. It was anticipated that with larger versions of this reactor incorporating these improvements the conversion ratio could be raised to 0·5; other types of reactor might achieve even higher ratios.

Dr. J. J. Went of the Netherlands, who asked if the uranium alloy used in the reactor was uranium-molybdenum, received the reply that this would of course be possible. Dr. J. V. Dunworth of the Atomic Energy Research Establishment at Harwell inquired if the Soviet Union intended to build a large number of the type of reactor described, and was informed that larger and improved versions would be constructed. He also asked for confirmation of a statement by Malenkov that a 100,000-kW nuclear power plant was being built in the U.S.S.R. and would be in operation in about one year. This was confirmed.

In reply to a question by Mr. B. L. Goodlet of A.E.R.E., Professor Blokhintsev stated that the radioactivity of the water drained from the reactor primary coolant circuit was 10 microcuries. Dr. J. Shankar of the Indian Atomic Energy Establishment asked how much decomposition of water (a mixture of the products can be explosive) was caused by the effect of radiation on the primary coolant circuit and what was done to overcome this. The reply was that, while such decomposition occurred at low pressures and temperatures, there was no substantial decomposition at the 100-atmosphere pressure and the temperatures of from 200 to 300 deg. C. employed in the Soviet reactor. Thus no explosive mixture was created.

In noting that the fuel elements were cooled internally and not externally, Dr. A. M. Weinberg of the Oak Ridge National Laboratory, U.S.A., asked if this gave rise to faults due to unequal expansions of the fuel-element materials. The answer was that the thin outside wall of the fuel element was made of a plastic (flexible) material so no problem arose. Dr. Weinberg continued by inquiring if the wall or jacket was bonded to the fuel. Professor Blokhintsev replied that there was a " molecular liaison " between the two.

### U.S. BOILING-WATER REACTOR

Following this discussion Dr. W. H. Zinn, Director of the Argonne National Laboratory, summarised a paper entitled " Design and Operating Experience of a Prototype Boiling Water Power Reactor." This reactor produces steam directly inside the vessel containing the reactor core and thus does not need a heat exchanger. Also, since the reactor coolant is permitted to boil, much lower pressures are possible. Moreover, since steam is produced directly, lower temperatures can be used in the reactor. The construction metals are therefore less subject to corrosion, which is hastened with increasing temperature. The reactor employs uranium or thorium fuel elements clad in zirconium, while aluminium serves as the main structural material. The plant cost 550,000 dols.

Experiments with the boiling reactor have been in progress for two years and have shown that it is inherently safe. Several reactor cores (assemblies of fuel elements) have been studied. One core of heating rating 15,000 kW has powered a turbo-generator with an electrical output rating of 3,500 kW, and a core which has been in operation only a short time has produced 3,000,000 kWh. of energy in the form of steam. Operating experience has shown that it is " practically impossible to get into difficulties through misoperation."

Measurements of radioactivity induced in the steam indicated that the major part of it arose from nitrogen 16, a short-lived radioisotope. Higher activity at the condenser was found to be caused by sodium 24, which came from the demineraliser (chemical remover of water impurities), and from leakage of condenser cooling water, which is taken from a well of high sodium content.

A cost summary led to the conclusion that, depending on the price of uranium fuel, power would cost 30 to 35 mills (one mill equals one-tenth of a cent) per kilowatt-hour. This is less than double the cost of power produced by coal-fired plants of the same size.

### POWER LIMIT AND STEAM VOIDS

The first speaker in the subsequent discussion was Dr. G. N. Kruzhilin, corresponding member of the U.S.S.R. Academy of Sciences, who observed that, based on Soviet Union experience and calculations, there appeared to be a practical limit to the size of a boiling reactor, and hence the power, that it could produce. There was only a certain surface area on which boiling could occur and from which steam could escape, thus a restriction was imposed by the limitations of pressure vessels. He considered the maximum possible diameter of such a vessel was 2 m., and the output therefore, at operating pressures between 20 and 30 atmospheres, 60 tons of steam per hour.

Dr. Zinn believed that up to a million kilowatts of heat could be produced from a boiling-water reactor. Since pressures were modest, the reactor pressure vessel could with present technology be as much as 4 m. in diameter, and since the output was proportional to the square of the diameter this gave a considerable increase. Moreover, forced circulation of the cooling water and the use of a " dual cycle " in which part of the reactor water is diverted to another steam-producing system (flash-over) would permit even greater power output. He did not think the boiling-water reactor was limited in size.

Mr. B. L. Goodlet, of A.E.R.E., stated that the major problem with boiling reactors was that steam voids and bubbles increased as power rose; these voids affected the reactivity and led to instability. There was also a question of safety: if a break in the system occurred causing steam flash-over, the residual water would be cooled and perhaps give rise to excess reactivity. In his answer Dr. Zinn stated that a fault of this kind had been studied experimentally and it was found that within the 30 to 40 seconds required for the condition to arise the control rods would fall and shut down the reactor.

In reply to a question by Dr. Dunworth concerning the presence together of coolant water and aluminium structural materials, and the consequent possibility of reaction between them, leading perhaps to chemical or nuclear explosions, Dr. Zinn stated that even when the aluminium was in considerable thickness this difficulty had not arisen. In fact the aluminium was distributed in small quantities; however, such a reaction could occur and the possibility should not be overlooked.

* " The First Atomic Power Station of the U.S.S.R. and the Prospects of Atomic Power Development," D. I. Blokhintsev and N. A. Nikolayev.

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## DEEP-SEA TELEPHONE REPEATERS

### Precautions in Manufacture

As already recorded in ENGINEERING the 52 repeaters, which are to be incorporated in the deep-sea section of the submarine telephone cable between this country and Newfoundland, are being manufactured by the Western Electric Company at their Kearney works in New Jersey. In performing this work special precautions have been taken in the shops to prevent contamination, and the temperature, humidity and air supply are accurately controlled. Orlon clothing is worn by the operators and the gold-plated containers employed to house the paper capacitors are cleaned with a solvent before entering the factory. They are then boiled in distilled water for ten minutes, a beaker of special glass being used for this purpose. This distilled water is prepared in a distillery on the site and thence piped to all the working areas. All metal parts incorporated in the repeaters are washed with detergent and distilled water and then with medicinal alcohol before assembly.

*Obituary*

## SIR ALAN H. L. MOUNT, C.B., C.B.E.

### Chief Inspecting Officer of Railways

We regret to record the death of Sir Alan Mount, which occurred in London on Wednesday, August 10, at the age of 74. As an Army officer he was in his early days engaged on railway work in India and subsequently was active in France in the same sphere of activity during the 1914–18 war. Later he became one of the Inspecting Officers of Railways under the Ministry of Transport, a position in which he was well known for the excellence of his reports on accidents and for the interest he took in the safety of the travelling public.

Alan Henry Lawrence Mount was born at Welwyn, Hertfordshire and was educated at Bradfield College and Coopers Hill, of which he was made a Fellow. He obtained a commission in the Royal Engineers in 1902, and after two years at the School of Military Engineering, Chatham and a year in the locomotive department of the Midland Railway was appointed assistant engineer on the North Western State Railway in India. In this capacity he was responsible for the operation of several subdivisions of the system in the Punjab, and in 1911 he constructed the light railways which were required for the Delhi Durbar. In the following year he prepared a scheme for a new passenger terminal and interchange yard for that city.

In March, 1914, he joined the staff of the Indian Railway Board, but on the outbreak of war went to France where he became Assistant Director of Railway Construction with the rank of lieutenant-colonel. Three years later he was appointed Deputy Chief Construction Engineer for broad gauge railways under Sir Eric Geddes, Director-General of Transportation.

Mount was appointed an Inspecting Officer of Railways in the Ministry of Transport in 1920 and nine years later succeeded Sir John Pringle as Chief Inspecting Officer, a position he held until his retirement in 1949. He was then appointed consultant to the Railway Executive on matters concerned with safety measures on British Railways. During his inspectorate he played a large part in connection with the maintenance of railways during the 1939–45 war and acted as chairman of a number of departmental committees. In 1939 he acted as chairman of the Pacific Locomotive Committee, which reported to the Government of India on the design of the XB class engines after the Bihta accident; and in 1941 received a knighthood for his work in this connection.

Sir Alan was appointed a Commander of the Order of the British Empire and received the Legion of Honour for his work during the 1914–18 war; and in 1931 became a Companion of the Order of the Bath. He was also the holder of the Kaiser-i-Hind Medal. He had been a Member of the Institution of Civil Engineers and of the Institute of Transport and had served on the Council of the latter body.

* * *

## MR. F. G. PENNY

### Boiler Maker

We also regret to record the sudden death of Mr. F. G. Penny, which occurred at Derby on Saturday, August 6, at the age of 66.

Frederick Gaston Penny was born on February 7, 1889, and was educated at Sale Council School. He received his engineering training at the Royal Technical School, Salford, and the Manchester School of Technology, and was apprenticed for three years to Mr. A. E. Matthewson of Geo. Richards and Company, Limited, Broadheath. In 1908 he joined the British Westinghouse Electric and Manufacturing Company as an assistant in the Electrical Test Department at Trafford Park. He was subsequently engaged with the same firm on the design of power plant in the Mechanical Drawing Office, as assistant to the Chief Mechanical Engineer on the design of steam turbines and in carrying out experimental work relating to new manufacturing processes and to the improvement of the works organisation.

In 1914 he was made responsible for the maintenance and operation of the Trafford Park works, his duties including the design, equipment and building of the numerous additions that became necessary during the war. Four years later he left the manufacturing for the supply side of the electrical industry on his appointment as constructional engineer in the Electrical Department of the Rotherham Corporation under Mr. E. Cross. In this position he was responsible for supervising extensions to the power station amounting to 55 MW and subsequently for its operation and maintenance.

From 1924 he was engaged for three years with the Shanghai Power Company, being responsible for the operation and maintenance of a 165-MW station, and in 1927 he joined the staff of the International Combustion Company, Limited, and the Underfeed Stoker Company, Limited, as technical engineer and manager of the field staff. In 1932 he was appointed general manager of the Derby works and chief engineer of the former company. In 1951 he became managing director both of this concern and of International Combustion (Holdings), Limited. He was also chairman of Aberdare Cables (Holdings), Limited.

Mr. Penny was elected an Associate Member of the Institution of Civil Engineers in 1915 and was transferred to the class of Members in 1942. He became an Associate Member of the Institution of Mechanical Engineers in 1917 and a Member in 1925.

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## SIR FRANCIS McCLEAN

### Astronomer and Pioneer Aviator

Although trained as a civil engineer, Sir Francis McClean, A.F.C., who died in London on Thursday, August 11, devoted practically the whole of his life to aviation of which he was one of the pioneers. Born on February 1, 1876, Francis Kennedy McClean was educated at Charterhouse and Clifton College and on leaving school spent a year at the College of Science and at Camborne, Cornwall. He entered the Royal Indian Engineering College, Coopers Hill, in 1894, passing out in 1897. He was appointed to the Public Works Department, India, in the following year and served in the Bombay Presidency for a few years but retired in 1902.

His first experience in aviation was with balloons in 1907 when he acted as assistant to Mr. Griffith Brewer in the Gordon-Bennett race starting from Berlin and landing near Bremen 29 hours later. In the following year, McClean took Griffith Brewer's place in the race which started from Zürich. Later in the same year he met Mr. Wilbur Wright and was thus introduced to aircraft of the heavier-than-air type. He ordered one of the first six Wright machines built in this country by Short Brothers, Rochester, and had another built by the same firm on somewhat different lines. This apparently never flew, but the Wright machine made a number of cross-country flights.

Francis McClean had a background of science and engineering, his grandfather, J. R. McClean, M.P., having been President of the Institution of Civil Engineers in 1864–65 and his father, Dr. Frank McClean, F.R.S., having achieved a reputation for his astronomical work in connection with solar and stellar spectra. In 1905 the subject of our memoir accompanied an expedition to Majorca, under Sir Norman Lockyer, to observe a total eclipse of the sun. He took part in some other eclipse expeditions and in 1913, after the closing of the Solar Physics Observatory in South Kensington, founded a new observatory in Sidmouth, Devonshire, afterwards known as the Norman Lockyer Observatory. One of the principal instruments of this observatory was a twin telescope with 10-in. and 12-in. object glasses previously used by his father in his spectroscopic work.

After returning from an eclipse expedition in 1910, McClean obtained his aviator's certificate from the Royal Aero Club. A long co-operation with Short Brothers in developing heavier-than-air craft followed, experiments being carried out at Eastchurch, in the Isle of Sheppey, on land bought by McClean and let to what is now known as the Royal Aero Club at a nominal rental. Interest grew rapidly and in 1911 the Admiralty accepted McClean's offer to lend aircraft to enable naval officers to learn to fly. One of his exploits in the following year was to fly a seaplane up the Thames from the Isle of Sheppey, passing under the Tower Bridge and the other intermediate bridges and alighting at Westminster Pier.

Immediately after the outbreak of the first World War in August, 1914, he joined the Royal Naval Air Service and served for a short period with the North Sea Patrol but later was made chief instructor at Eastchurch. He was given a commission in the Royal Air Force but resigned in 1919 after the end of the war. He was Chairman of the Royal Aero Club in 1923-24 and again from 1941 to 1944, afterwards being elected Vice-President.

He was unquestionably one of the leading pioneers in aviation and will long be remembered for the skill and courage he displayed in the early days of flying. He was awarded the Air Force Cross for his war services, was created a Knight in 1926, and was a Fellow of the Royal Aeronautical Society.

* * *

## MR. T. LAWRIE, C.B.E.

### Water Power in Scotland

We also regret to record the sudden death of Mr. T. Lawrie, which occurred in Edinburgh on Saturday, August 13, at the early age of 54. During his professional life he had been closely connected with the development of water power for electrical generation, especially in Scotland.

Thomas Lawrie was born at Laurencekirk, Kincardineshire, on March 8, 1901, and was educated at Mackie Academy, Stonehaven, and Leighton Park School, Reading. After leaving school he was for a short time with the Bethlehem Steel Corporation at Quing, Massachusetts, while from 1920 to 1923 he attended Cambridge University and was successful in the Mechanical Science Tripos. He then served his apprenticeship with the English Electric Company at Stafford, subsequently becoming an assistant engineer in the Hydro-Electric Department of the same firm.

In 1928 he was appointed engineer and secretary of the Power and Traction Finance Company Limited, and was engaged with them in connection with electricity supply schemes for the Sudan Light and Power Company and the Wad Medani Light and Power Company. He was also concerned with the promotion of the Galloway Water Power scheme and was appointed secretary to that company in 1939. During the first part of the 1939-45 war he served in the Royal Naval Volunteer Reserve, but in 1943 became secretary of the North of Scotland Hydro-Electric Board and was promoted to the position of general manager, a post he was occupying at the time of his death, five years later. While holding this post he was responsible for work in connection with the numerous water power schemes that were and are being constructed in the north of Scotland.

Mr. Lawrie was made a Commander of the Order of the British Empire in 1953. He was a Fellow of the Royal Society of Edinburgh. He joined the Institution of Mechanical Engineers in 1937 as an Associate Member and was transferred to the class of Member in 1950. In 1928 he was elected an Associate Member of the Institution of Electrical Engineers and became a Member in 1937.

# Letters to the Editor

## CONDITIONS FOR SUPPLY OF PLANT AND EQUIPMENT

### Part Played by the B.E.A.M.A.

SIR, The summary of the Report of the United Kingdom Trade Mission to Egypt, the Sudan and Ethiopia appearing in your issue of August 5 contains the following sentence: "The British Electrical and Allied Manufacturers' Association are asked to consider the possibility of adopting the General Conditions for the Supply of Plant and Equipment prepared by the United Nations Economic Commission for Europe."

I would point out not only that the B.E.A.M.A. played an indirect part in the formulation of the U.N.O., E.C.E. conditions by reason of the fact that its Legal Adviser is a member of the United Kingdom delegation appointed by H.M. Government to the working party which produced the conditions, but also that the Association adopted the conditions as soon as they were published and has consistently advocated their adoption by all exporters of engineering plant and machinery. Your summary of the Trade Mission's Report is therefore not only in this respect inaccurate, as a reference to paragraph 170 (iv) of the Report itself will quickly show, but misleadingly suggests that this Association has been backward in a matter in which it has in fact taken an energetic lead.

Yours faithfully,
K. F. A. JOHNSTON,
Legal Adviser.

The British Electrical and Allied
Manufacturers' Association,
36 and 38 Kingsway,
London, W.C.2.
August 11, 1955.

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## TORSIONAL VIBRATION IN MARINE PROPELLERS

### Damping Considerations

SIR, In reply to my comment of July 15, Mr. Archer makes clear the meaning he attaches to the term "efficient" as he applies it to a propeller functioning as a damping device. He also supplies the missing context in which he intended the statement in question to be read.

In view of this explanation it is surprising that he now confines this statement to the one-node mode since he suggests that the propeller may remain "intrinsically efficient" in multi-node modes, even though it may be dissipating little energy.

Whereas Mr. Archer uses $\frac{\Delta E}{E}$ as a measure of efficiency, the writer has from the outset assessed the effectiveness of the propeller as a damping device by the ratio $\frac{\Delta E}{S}$, where:

$\Delta E$ = damping energy dissipated by the propeller per cycle;
$E$ = maximum kinetic energy of the propeller during a cycle;
$S$ = total vibrational energy contained in a complete vibrating system in steady state.

It was with respect to this latter measure of efficiency that the writer ventured to criticise Mr. Archer's statement. In the one-node mode, where E is often of the same order as S, the two definitions are roughly equivalent and equally descriptive of the true role of the propeller. In multi-node modes only the ratio $\frac{\Delta E}{S}$ accurately describes the propeller as a relatively *inefficient* dissipator of energy, since S is usually much greater than E. Only with respect to the writer's definition of efficiency need the statement in question be confined to one-node modes.

Because our understandings of the term "efficient" differ and because his interest is confined to heavy-oil marine engine installations, Mr. Archer has misconstrued the writer's reference to the relative role of propeller and internal damping in turbine installations.

Yours faithfully,
J. P. DUNCAN.

Engineering Department,
University of Manchester,
Manchester, 13.
August 11, 1955.

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## ENGINEER OR TECHNICIAN?

### A False Line of Demarcation

SIR, One of the curses of the age, though there is nothing new about it, is the pigeon-holing of people into categories. The older industries such as iron making and working, or textiles, all have many strange outlandish names, hardly understood by most people nowadays, defining the various crafts involved. A glance at the situations vacant columns in the technical or general Press gives a modern equivalent. The demand is for technologists, metallurgists, physicists, draughtsmen, stressmen, estimators, designers, design engineers, designer-draughtsmen, etc., etc., and a wide variety of technicians and engineers of one kind or another. The daily Press is full of articles mentioning "young scientists" as if they were a separate race; and the lack of appreciation by the country as a whole of the source and origin of our only means of national existence, engineering and industrial enterprise and efficiency, is probably reflected in the muddled definitions applied to those who are trying to maintain it.

The word "engineer" means many different things to different people, from the creator of the Forth Bridge to the man who adjusts an electric bell. Presumably as a start in trying to clear this confusion the engineering institutions have agreed on definitions of a Professional Engineer, and an Engineering Technician, and have boldly published them (see ENGINEERING of January 21, 1955, vol. 179, page 69).

It would be difficult to find a more glaring instance of Victorian snobbery at its very worst. There you see the ENGINEER, right up in the clouds, standing on his dignity, and giving an occasional supercilious glance down at the technician who is doing his work for him! It really will not do. We are too late in the field to impose legal restrictions on the use of the word engineer—or equivalent—without specific qualifications, as some countries have done, but this definition is just not good enough. It practically excludes real leadership which, in any engineering work, involves not so much telling people what to do as showing, by precept and example, how to do it.

Personal experience of the work of the "technician," particularly as described in the list of his duties, in the final paragraph, is the essential training for, and forms much of the work of, the engineer, but this detailed demarcation savours of the worst of the restrictive practices of the trades unions. It would be interesting to hear what the great engineers of the past, when we led the world in engineering matters, would have had to say on the subject, particularly on the shade of meaning associated with the use of the word "technician" nowadays, and also on the phrase "sales engineering."

Yours faithfully,
HUGH CLAUSEN.

August 10, 1955.

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## DRAWING AND DESIGN

### The Way to Reduce Development Costs

SIR, I do not remember ever having met Mr. Clausen, but I read his article in the June 24 issue of ENGINEERING entitled "Drawing and Design" and it reads like the words of an old friend. I have rarely been so impressed.

Every word he says I believe to be perfectly true, and if only it were understood by engineers in general and scientists in particular, I am sure that development costs could be reduced enormously.

Yours faithfully,
A. THOMAS,
Chief Designer.

Armstrong Siddeley Motors, Limited,
Coventry.
August 8, 1955.

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## TITANIUM

### Improvements in Quality and Availability

SIR, Your contributor, Mr. P. W. Wigram, writing in your issue of August 5 on "The Newer Metals" quite properly includes titanium among the several metals he mentions, but his statement with reference to this country that "the quality of some of the material supplied has fallen well below expectations" might give the false impression that this refers to titanium of British manufacture and that its quality had disappointed actual and potential users.

The production of this metal involves the use of processes and techniques new to industrial metallurgy, and since 1947, when the total output was but two tons, methods have been continually improved. These improvements, and the increase of world production to its current level of about 5,000 tons per annum, have been accompanied by progressive improvement in purity and quality. With a new material and new manufacturing methods this is natural and to be expected, and users in this country have been at no disadvantage compared with those elsewhere on the score of quality of material available to them in this developing period. Indeed, in recent months the principal users in this country have commented most favourably on the quality of material produced here compared with titanium products which they have had from other sources.

While your correspondent is correct in suggesting that the demand for the material is at present mainly for the aircraft industry, he is quite wrong in stating that "none is available for anyone else." It is true that supplies are limited but it is equally true that the company with which the undersigned is associated has not found it necessary to decline, on these grounds, any order that it has received and it would welcome inquiries from those who might be interested in other uses for this metal and its alloys.

Yours faithfully,
MAURICE COOK,
Metals Division,
Joint Managing Director.

Imperial Chemical Industries, Limited,
Kynoch Works,
Birmingham.
August 12, 1955.

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## TITANIUM BULLETIN

The first number of a new publication, entitled *Titanium Abstract Bulletin*, issued by Imperial Chemical Industries Limited, Metals Division, Birmingham, has just made its appearance. As its name implies, the publication contains brief summaries of articles and reports culled from periodicals and journals, issued in all parts of the world, on the properties and characteristics, rolling, forging and working, melting, machining and joining of titanium and its alloys, and on their uses and applications. Abstracts of published information on titanium carbides, oxides and other compounds, the geology of the metal, production statistics, and other matters of interest are also included. The *Bulletin* contains 55 pages, measuring 6 in. by 9¼ in., and is well printed and produced. There are three to four abstracts on each page.

# PERSONAL

LORD BALFOUR OF INCHRYE, P.C., M.C., has joined the board of the British European Airways Corporation as a part-time member.

SIR PERCY H. MILLS, Bt., K.B.E., who has served as chairman of the National Research Development Corporation since its establishment in June, 1949, has asked the President of the Board of Trade to allow him to relinquish this appointment for business reasons. SIR ALAN A. SAUNDERS, O.B.E., a member of the Corporation since June, 1954, has now succeeded Sir Percy as chairman. His appointment is for four years. Sir Percy Mills has recently been elected a director of Electric and Musical Industries Ltd., Hayes, Middlesex.

MR. J. G. WISTREICH, M.Sc.(Eng.), A.M.I.Mech.E., has been appointed deputy head of the Mechanical Working Division of the British Iron and Steel Research Association, Hoyle-street, Sheffield, 3, while continuing in his present capacity as head of the Association's metal-working laboratories in Sheffield.

BRIGADIER F. C. WALLACE, D.S.O., M.C., has joined the board of Decca Radar (Canada) Ltd., the head offices of which are in Toronto.

MR. J. W. BARKER, chairman and President of the Research Corporation, New York City, has been nominated to serve as the next President of the American Society of Mechanical Engineers, 29 West 39th-street, New York 18, U.S.A.

MR. C. E. G. BAILEY, M.A., M.I.E.E., who, for some time has been a consultant to the Solartron Electronic Group Ltd., Thames Ditton, Surrey, has been appointed technical director of Solartron Electronic Business Machines Ltd. He will also act in a general advisory capacity on research and development work to the Group.

REAR ADMIRAL N. E. DALTON, O.B.E., has been appointed for duty with the Engineer-in-Chief, the Admiralty, Bath, and as a deputy Engineer-in-Chief, in succession to REAR ADMIRAL I. G. MACLEAN, C.B., O.B.E., with effect from October 3.

Siemens Brothers & Co. Ltd., announce that MR. H. E. HUMPHRIES has relinquished his directorship of the company and that the board have appointed DR. J. N. ALDINGTON, M.I.E.E., managing director.

MR. J. A. BROUGHALL, executive officer (electrical engineering, new works and development) British Railways Central Staff, has been made electrical engineer (development) chief electrical engineer's department.

British Railways (London Midland Region) announce the following staff appointments. MR. T. FISKE is to be assistant to the general manager (modernisation) Euston; MR. R. L. MCILMOYLE, assistant civil engineer (modernisation) Euston; MR. A. H. EMERSON, assistant electrical engineer (modernisation) Derby; MR. C. G. DERBYSHIRE, assistant signal engineer (modernisation) Euston, and MR. D. J. JEWELL, divisional signal engineer, Manchester.

MR. E. H. BOWERS and MR. D. E. WISEMAN have been elected to the board of Dowty Hydraulic Units Ltd., Cheltenham, the former as director and chief designer and the latter as director and general manager.

MR. P. D. OSBORN, B.Sc.(Eng.), A.M.I.E.E., has been appointed to succeed MR. R. V. POWDITCH, O.B.E., T.D., A.M.I.E.E., A.M.I.Mech.E., as sales manager, fractional horse-power motors, to Crompton Parkinson Ltd., Crompton House, Aldwych, London, W.C.2. MR. C. J. HURD, formerly manager of the Crompton Parkinson sub-office at Leicester, has been appointed to succeed MR. J. D. HAMMOND as branch manager, Home Counties, at Chelmsford.

MR. H. J. WHITEHEAD has been appointed sales manager to John Ingham & Sons, Ltd., colliery engineers, Middlestown, Wakefield.

MR. W. HILTON, purchasing officer to the London Transport Executive, 55, Broadway, London, S.W.1, has retired after 50 years of service with the Executive and its predecessors. Mr. Hilton's successor is his senior assistant, MR. R. L. P. COBB.

DOWDING & MILLS LTD., Bordesley, Birmingham, 12, announce a reorganisation owing to the further expansion of their London business. MR. P. L. HOLLINGS, formerly assistant to the general manager retains his position as London manager. MR. P. A. CHAMBERS, the N.E. London area technical representative has been appointed works superintendent and MR. V. H. DEVIS is to take over the N.E. London area as technical representative. MR. D. A. W. CLARK, B.Sc.(Eng.), has now assumed control of the southern area as technical representative, while MR. R. P. F. TODD remains technical representative for the N.W. London area. MR. W. L. HENDERSON, A.M.I.E.E., retains his position as London sales manager. The firm's London offices are at 24–26 Whitepost lane, Hackney, E.9.

MR. ARTHUR EVANS, who has been with the flexible plastics division of Dunlop Special Products Ltd., since the beginning of the year, has been appointed assistant sales manager to the firm.

MR. E. C. BECK, of the Mowlem Paving Co. Ltd., has been elected chairman of the British Tarpaviors' Federation, 47, Victoria-street, London, S.W.1, for the current year, in succession to MR. R. PRESTON-HILLS, who had held the office for two years.

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# COMMERCIAL

IGRANIC ELECTRIC CO. LTD., announce that ALAN COLLESS PTY. LTD., have appointed CLARK-STRICKLAND PTY. LTD., 17 McKillop-street, Melbourne, C.1, Victoria, Australia, to act as their agents for Igranic motor control gear throughout the State of Victoria.

WICKMAN LTD., Banner-lane, Tile Hill, Coventry, as from September 1, will assume the sole agency for the products of ARTHUR SCRIVENER LTD., Tyburn-road, Birmingham.

THE BRITISH MOTOR CORPORATION LTD., Longbridge, Birmingham, have formed a subsidiary company, B.M.C. SERVICE LTD., with the object of co-ordinating all service operations within the group and bringing them under central control.

HEENAN AND FROUDE LTD., Worcester, and the MARLEY CO., of Kansas, U.S.A., have entered into an agreement for the production of Heenan-Marley water coolers. Under this agreement the British company, as exclusive licencees, will manufacture coolers for practically all countries outside North and South America.

MR. A. C. WILSON, late of Wilson & Rodger, has formed, in association with the POWER-GAS CORPORATION LTD., the firm of A. C. WILSON AND PARTNERS LTD., design engineers, Design House, The Mall, Ealing, London, W.5. (Telephone: EALing 9843 and 1942). The company undertakes all classes of design work, including complete projects, connected with all branches of engineering.

THE ATLAS DIESEL CO. LTD., Wembley, Middlesex, have moved their Bristol branch to larger premises at 47A, Zetland-road, Bristol 6. (Telephone: Bristol 45036/7). The branch manager is MR. W. J. CLARKE.

YOUNGS (LIFTING APPLIANCES) LTD., Ryland Street Works, Birmingham, 16, have appointed OSWALD RECORD & CO. LTD., 17, Victoria-street, London, S.W.1, (Telephone: ABBey 2908) as their agents for London and the Home Counties. Their representative for this district, MR. H. COOMBE, has joined the staff of Messrs. Oswald Record and, in future will be available at 17 Victoria-street, in place of the former office at 430, The Strand, W.C.2.

BRITISH INSULATED CALLENDER'S CABLES LTD., announce that the telephone number of their London branch sales office, 10–14 White Lion-street, London, N.1, is now TERminus 2701.

METAL INDUSTRIES LTD., Universal House, 60 Buckingham Palace-road, London, S.W.1, announce an addition to their telephone lines and changes in numbers. SLOane 5587 is superseded by SLOane 7192, 7193 and 7194. SLOane 5814 and 5618 remain in service.

Q.V.F. LTD., Mill-street, Stone, Staffordshire, have now a new telegraphic address, namely, " Glass-plant Stone."

SUNVIC CONTROLS LTD., No. 1 Factory, Eastern Industrial Estate, Harlow, Essex, inform us that the telephone number of their accounts and sales departments has been changed to Harlow 25271.

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# CONTRACTS

**Reactor Vessels at Calder Hall.** At Calder Hall, Cumberland, WHESSOE LTD., Darlington, are erecting the two steel reactor casings inside the pile buildings. These casings form protective shells within which nuclear fission, controlled by a graphite moderator, will take place. Whessoe Ltd. have recently received further contracts from the United Kingdom Atomic Energy Authority for two more reactor shells at Calder Hall and for a set of four for construction at Annan, Dumfriesshire.

**Electricity-Generation Plant.** Orders for turbo-alternator sets totalling some £2¼ million have been placed with the GENERAL ELECTRIC CO. LTD., Magnet House, Kingsway, London, W.C.2, by the Central Electricity Authority. They comprise one 120 MW and two 60 MW sets in which the alternators will be direct-cooled by hydrogen. Steam conditions in the reheat cycle turbo-alternator of the 120 MW set will be 1,500 lb. per sq. in. gauge pressure and 1,000 deg F., with reheat to 1,000 deg. F. The machine will have high-pressure, intermediate-pressure and low-pressure cylinders arranged in a single line, with turbine and generator rotors rigidly coupled and a single thrust bearing. The contract includes the supply of a condenser having a cooling surface of 70,000 sq. ft., and a six-stage feed-heating plant. For an output of 120 MW the designed vacuum will be 28·9 in. of mercury and the final feed temperature, 435 deg. F. The two 60 MW sets will operate at steam conditions of 925 deg. F., and 900 lb. per sq. in. gauge pressure, the vacuum at full output being 28·9 in. of mercury.

**Short-Wave Radio Transmitters.** The British Post Office has awarded a contract for the supply of twenty-three 30-kW short-wave transmitters to STANDARD TELEPHONES AND CABLES LTD., Connaught House, Aldwych, London, W.C.2. The transmitters will incorporate remotely-controlled frequency selection and give very-high linearity of performance. The equipments will be installed at three of the British Post Office radio-transmitting stations and will be used for point-to-point multi-channel telephony and telegraphy services between the United Kingdom and all parts of the world.

**Diesel-Electric Shunting Locomotives.** A repeat order for six 300-h.p. 0-4-0 Diesel-electric shunting locomotives has been received by BRUSH-BAGNALL TRACTION LTD., Loughborough, from the Steel Co. of Wales Ltd. This is in addition to an earlier order for seven similar locomotives which have now been completed. The traction motors, control gear, and main generators of the locomotives will be manufactured by the BRUSH ELECTRICAL ENGINEERING CO. LTD., Loughborough; the six-cylinder pressure-charged Diesel engines, developing 300 h.p. at 1,200 r.p.m., by the NATIONAL GAS AND OIL ENGINE CO. LTD., Ashton-under-Lyne; and the mechanical parts by W. G. BAGNALL LTD. The complete locomotives will be assembled in the Brush Bagnall locomotive erecting shop at Loughborough.

**Radio Receiving Equipment.** The Government of Iran is to modernise its radio communications system to Europe and various overseas countries by the setting up of a high-quality independent sideband radio-telephony and telegraphy service. An order for the supply and installation of the complex receiving equipment has been obtained by MARCONI'S WIRELESS TELEGRAPH CO. LTD., Chelmsford, Essex, and, in addition, the firm are to train Iranian engineers in the use of the equipment. The order includes the supply and installation of the firm's double-diversity high-frequency telegraph receivers, single-path receivers, tone senders and converters, terminal equipment, and channel shifting and restoring equipment.

**Continuous Medium-Strip Rolling Mill.** An order for a continuous medium-strip rolling mill to be installed in the Ilva Steelworks, Italy, has been secured by the LOEWY ENGINEERING CO. LTD., Wallisdown-road, Bournemouth. The mill, which is valued at £500,000, is to be delivered by the end of 1956. The plant is similar to, but smaller in size than, the continuous strip rolling mill which is being built by the same firm for the Steel, Peech and Tozer branch of the United Steel Companies, Ltd.

**River Bridge.** The successful tenderers for a river bridge, to cost £A71,800, for the Department of Main Roads, New South Wales, Australia, are HORSELEY BRIDGE AND THOMAS PIGGOTT LTD., Horseley Works, Tipton, Staffordshire. The bridge, 716 ft. long, by 40 ft. wide, is to span the Karuah River on the Shires of Stroud and Port Stephens State Highway No. 10.

**Motor Launch.** The Corporation of Trinity House, London, has placed an order with JOHN I. THORNYCROFT & CO. LTD. for an experimental fast pilot launch. The design has been evolved between Trinity House and Messrs. Thornycroft, and is a departure from previous Trinity House practice. The vessel will accommodate 12 pilots for short periods and will have an overall length of 70 ft. and a beam of 15 ft. Her hull will be double-skin mahogany, heavily fendered, and her propelling machinery will consist of twin Rolls-Royce C8 Diesel engines, giving her a speed of 15 knots. She will have twin rudders and will be equipped with radar and both medium and very high frequency radio-telephone sets. Delivery is expected within a year.

# GAS SALES AND SERVICES

## *Scottish Conferences*

Preliminary arrangements for the fourth gas sales and services conference, organised by the Gas Council, have now been completed. The conference, as already announced, will be held at the "Heads of Ayr" Holiday Camp, Ayr, Scotland, from Monday, September 12, to Wednesday, September 14, 1955. There will be morning sessions each day and afternoon sessions on September 12 and 13.

These sessions, some of which will take place simultaneously, will deal with such subjects as the news value of the gas industry, market research and selling arrangements, the relative sales value of shops and showrooms, services to consumers, the importance of films to the industry, factors influencing the sale of gas to industrial concerns, the development of the Team Valley Trading Estate, immersion and radiant tube heating, and the future development of markets for gas. Two papers to be read at the final session will deal with the post-entry training of home service advisers and modern methods of fruit and vegetable preservation. The opening proceedings will include an address by Sir Harold Smith, K.B.E., chairman of the Gas Council, there will be an evening civic reception on September 13, and the conference will conclude with a luncheon to home service delegates on September 14.

Further information may be obtained from the Press and Information Office, Gas Council, 1 Grosvenor-place, London, S.W.1.

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# NUCLEAR POWER IN AMERICA

## *Five-Year Reactor Construction Programmes*

Two approaches to the development of large-scale power-reactor technology are under way in the United States. These are (*a*) the Atomic Energy Commission's five-year civilian power reactor programme; and (*b*) power reactor proposals by industries. We publish below details of the two programmes as given in the paper "Economics of Nuclear Power," presented by James A. Lane, of the Oak Ridge National Laboratory, U.S.A., to the International Conference on the Peaceful Uses of Atomic Energy. The corresponding United Kingdom proposals were given in *A Programme of Nuclear Power*, which was summarised in ENGINEERING on February 25 of this year.

TABLE I.—*U.S.A.E.C. Five-Year Civilian Power-Reactor Programme*

| Reactor type | A.E.C. laboratory | Power (MW) | | Cost, (millions of dols.) | Estimated completion |
|---|---|---|---|---|---|
| | | Heat | Electricity | | |
| Pressurised water (PWR) | Westinghouse | 264 | 60 | 85 | 1957 |
| Boiling water (EBWR) | Argonne | 20 | 5 | 17 | 1956 |
| Sodium graphite (SGR) | North American | 20 | — | 10 | 1956 |
| Fast breeder (EBR-2) | Argonne | 62·5 | 15 | 40 | 1958 |
| Homogeneous reactor test (HRE-2) | Oak Ridge | 5 | 1 | 3 | 1956 |
| Homogeneous thorium breeder (TBR) | ,, ,, | 65 | 16 | 44 | 1959 |

TABLE II.—*U.S. Industrial Power-Reactor Proposals.*

| Reactor type | Sponsoring group | Power (MW electricity) | Cost (millions of dols.) | Estimated completion |
|---|---|---|---|---|
| Pressurised water | Yankee Atomic Electric | 100 | 24 | 1957 |
| Boiling water | Commonwealth Edison (Nuclear Power Group) | 180 | 45 | 1960 |
| Sodium-graphite | Consumers' Public Power District | 75 | 24 | 1959 |
| Fast breeder | Detroit Edison .. | 100 | 45 | 1958 |
| Pressurised water | Consolidated Edison | 236 | 55 | 1959 |

The A.E.C. programme involves the construction of one full-scale pressurised-water reactor power plant and intermediate or small-scale prototypes of other forms of reactor which show promise of achieving low-cost nuclear power. These are listed in Table I. Approximately 200 million dols. will be required to support the programme.

A more venturesome reactor programme involving the construction of full-scale nuclear plants is being considered by various industrial groups in the United States. These are listed in Table II. Except for the Consolidated Edison reactor, which is likely to be built entirely with private funds, the proposals involve some help from the U.S. Government. This help includes the waiving of established A.E.C. charges for the loan of nuclear fuel and fertile material for a period of up to seven years, support without charge by A.E.C. laboratories, and advance payment by A.E.C. for technical and economic information gained. If all these plans are carried into operation, the installed nuclear plant capacity in the United States will be some 800,000 kW of electricity by 1960.

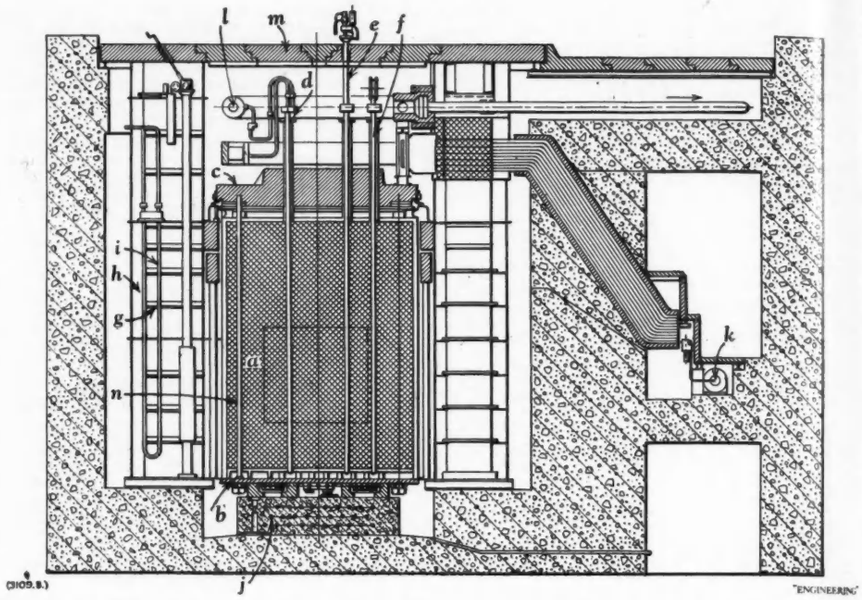


**Fig. 1 Layout of reactor, showing graphite masonry (a), lower plate (b), upper plate (c), fuel channel (d), safety-rod channel (e), automatic control-rod channel (f), ionisation-chamber channel (g), lateral water shielding (h), refrigerator (i and j), inlet header (k), outlet header (l), upper shielding (m), and reflector (n).**

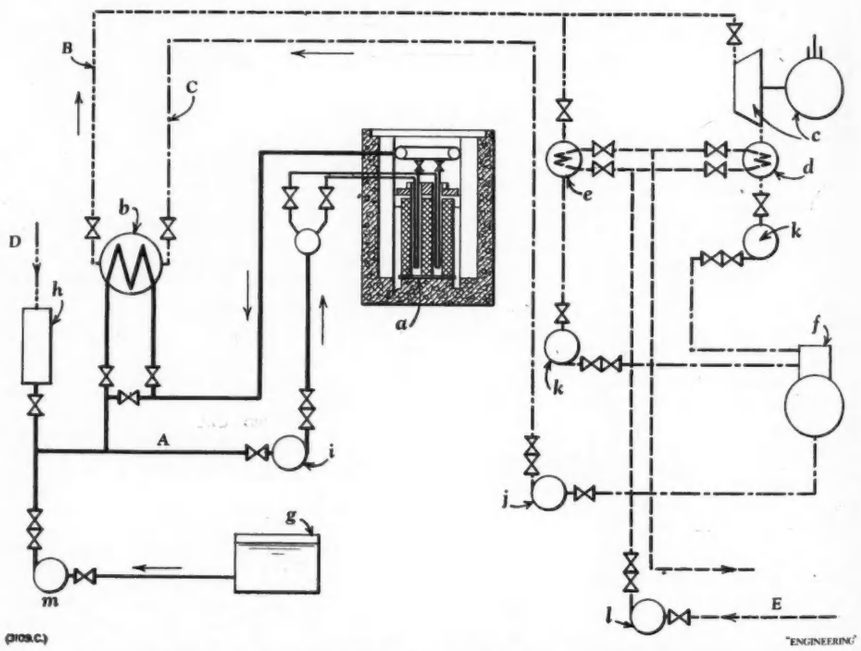


**Fig. 2 Power-station flow diagram. Reactor (a), steam generator (b), turbo-generator (c), turbine condenser (d), starting condenser (e), de-aerator (f), supplementary water tank (g), volume compensator (h) primary-circuit circulation pump (i), secondary-circuit feed pump (j), condensate pump (k), cooling-water pump (l), primary-circuit feed pump (m). Primary-circuit water at 100 atmospheres (A), steam at 12·5 atmospheres (B), secondary-circuit condensate (C), compressed air (D), cooling water (E).**

# THE FIRST ATOMIC POWER STATION IN THE SOVIET UNION

## HEAT TRANSFER BY WATER IN TWO CIRCUITS

*The construction of the first industrial atomic power station in the U.S.S.R. with an output of 5,000 kW was completed in* 1954, *and by June* 27 *of that year was already generating electricity from the fission energy of uranium nuclei. The station, which was built for the Soviet Academy of Sciences, employs a graphite-moderated thermal reactor cooled by pressurised water, and has been constructed primarily for the solution of the scientific and engineering problems involved in building larger stations of high reliability. A paper describing the new power station and assessing the prospects of atomic-power development was given by Professor D. I. Blokhintsev and Engineer N. A. Nikolayev to the International Conference on August* 9. *Excerpts from the paper are reproduced here in abridged form.*

### COOLING AND REACTOR CONTROL

The heart of the Soviet atomic power station, which is shown in Fig. 3, is a pressurised-water cooled thermal uranium-graphite reactor with a rated heat-generating capacity of 30,000 kW. The average flux of neutrons is $5 \times 10^{13}$ neutrons per square centimeter per second. The atomic fuel is enriched uranium containing 5 per cent. of uranium 235, and the total charge is 550 kilograms. The heat-transfer system consists of two circuits: the first, passing through the reactor contains water under a pressure of 100 atmospheres which delivers its heat through a series of heat exchangers to water in a second circuit. This transformed into steam drives a 5,000 kW turbo-generator. The use of a two-circuit system prevents radioactive contamination of the turbine and auxiliary equipment, so it can be operated without protective shielding as in a conventional power plant.

Water, which is a good coolant, was selected in order to simplify numerous engineering problems, but its presence in the reactor necessitated special attention to chain-reaction control. This is because with a moderating length of 5·7 cm. and a diffusion length of 2·8 cm. (the corresponding figures for graphite are 19 and 50 cm.), water is a rather strong absorber of neutrons. Thus the fission chain reaction is very sensitive to reactor water content, and this, particularly at high values, changes with temperature. Leakage from the fuel channels and the penetration of water into the graphite brickwork may also affect the rate of reaction. The effect of changes in water quantity depends largely on the ratio of uranium to graphite and the normal water content. Although it is possible to select graphite-uranium-water ratios at which the reactor is least sensitive to changes in water content, the actual quantity of water selected was less than that for minimum sensitivity, because otherwise it would have been necessary to increase the quantity of steel in the reactor.

### LOW PLUTONIUM PRODUCTION

The chain reaction in the reactor is characterised by rather high specific uranium heat removal; and the flow from the surface of the uranium is about $1·5 \times 10^9$ calories per square meter per hour. This together with the large heat flow and the considerable intensity of the neutron field lead to rigid requirements for the endurance of the uranium fuel elements.

The burnout of uranium 235 is 15 per cent. and owing to low resonance capture the production of plutonium from uranium 238 is small. The conversion ratio of the reactor is 0·32. Fast neutron multiplication is almost absent. Thus the reactor works almost exclusively by burning uranium 235 and the degree of enrichment decreases during the operation from 5 to 4·2 per cent.

### REACTOR DESIGN

Fig. 1 on page 232 shows the construction of the reactor. It is encased in a cylindrical steel pressure vessel mounted on a concrete foundation. This jacket, with suitable clearance, encloses graphite brickwork, and to avoid burn out of the graphite is filled with helium or nitrogen.

The central part of the brickwork is pierced by a total of 128 fuel channels, each of which consists of a long graphite cylinder containing thin-walled steel tubes carrying the primary-circuit water. The water passes through the upper head of the channel linked to the inlet and outlet headers, runs down through the tubes and returns up, flowing over the surface of the uranium fuel elements. These elements form a cylindrical active zone, 150 cm. in diameter and 170 cm. high, enclosed by a graphite reflector. In Fig. 1 the active zone is indicated by a dotted line.

The flow and temperature of the water are recorded for each channel and the indicating instruments are located on the central panel; they are connected with the safety rods which stop the chain reaction when the water flow exceeds prescribed limits or when the temperature rises above a permitted level.

At a pressure of 100 atmospheres water boils at 309 deg. C. If the temperature of the water in the channel reached this level, its boiling would cause a sharp heat-removal decrease and consequently overheating and possible destruction of the fuel element. It is therefore very important to control the outlet temperature of the water since this reflects the conditions in the channel. In practice this is effected by means of a scanning light signal indicating the channels where the temperature of the water is above the prescribed limit. There is in addition a separate plug panel for measuring the absolute temperature of the water in any desired channel. In addition, flow-meters record the conditions in the water channel.

### SHUT-DOWN AND SAFETY DEVICES

A decrease of flow leads to a rise in the outlet temperature; an increase indicates rupture of tubes in the channel or its connections. All these deviations are dangerous and lead to shut-down of the reactor by means of the safety rods. Other safety devices include a cut-off and non-return valve to prevent rapid filling of the reactor in the event of channel-tube rupture, which would lead to a rapid rise of reactivity; and a water and gas radioactivity monitor which thus indicates the existence of a rupture in the fuel elements by the resulting rise in activity.

To compensate the excessive reactivity of the reactor, 18 boron-carbide rods are installed, six near its centre and 12 at the extremities of the active zone. These rods move in special channels with a separate water-cooling system. There is a separate cooling system also for the graphite reflector. By means of wire ropes and servo-motors these rods are moved vertically and their position is registered at the central panel. With these rods it is possible to regulate the outlet temperature of the water in the fuel channels. The total submerged length of all the shim rods indicates the total excess of its reactivity and consequently, the above-critical quantity of atomic fuel. The fuel quantity may therefore be expressed in linear units and this is effected by means of a graduated scale.

Besides the shim rods there are four automatic regulation rods located in the reflector. Their position is changed automatically by servo-motors activated by ionisation chambers. If the chain reaction increases the rods fall, and if it diminishes they rise. One pair of rods works at a time, while the other pair is in reserve. These regulators maintain the chain reaction to within 3 per cent. accuracy.

Finally, there are two safety rods with servo-motors installed directly over the reactor's upper shield. In the event of an emergency these rods fall freely into the active zone of the reactor and thereby stop the chain reaction.

In all there are 12 different emergency signals. The most important of them indicate: 20 per cent. rise above the prescribed power level, too rapid increase of the chain reaction, shut-off of electric current to the main circulation pumps, and changes in the flow and temperature of the water in the fuel channels.

### SHIELDING

Biological shielding is provided by a side water shield 100 cm. thick and a concrete wall 300 cm. thick, while in the upper part of the reactor protection is given by intensification of the graphite reflector, by the upper steel cover of the installation and by a cast-iron plate. Since the shield capacity has been only approximately calculated, special attention in designing the reactor was devoted to the avoidance of channelling directions for fast neutrons or gamma rays. A possible direction would be that forming a small angle with the reactor jacket.

The reactor also incorporates a number of devices for physical investigations and tests of materials.

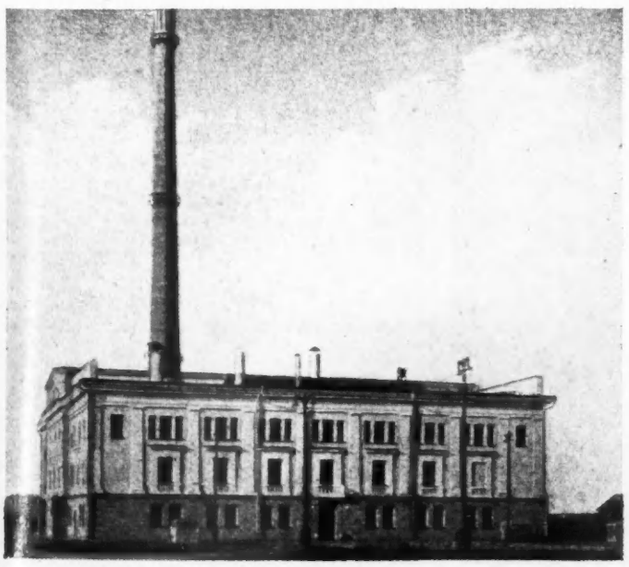

**Fig. 3 By June 27, 1954, the first industrial atomic power station in the U.S.S.R. was generating electricity. The station, which has an output of 5,000 kW, employs a pressurised-water-cooled graphite-moderated thermal reactor with a rated heat-generating capacity of 30,000 kW.**

### TWO-CIRCUIT WATER SYSTEM

As has already been mentioned the most characteristic feature of the station scheme is the two-circuit system. The heat-transfer agent is water, which circulates in the primary circuit under high pressure and carries the heat to the second circuit. In the steam generators the water is converted into steam, which passes to the turbine. The entire primary circuit is made of stainless steel and situated behind the biological shielding. The flow diagram for the system is shown in Fig. 2.

The water of the primary circuit is heated in the reactor channels to a temperature of between 260 and 270 deg. C. and passes to the steam generators from the header. There are eight such steam generators coupled in pairs in the shielded boxes. At peak power output, three pairs of steam generators are in operation and the fourth pair is in reserve. Each steam generator consists of a water heater, a water evaporator and a steam superheater. The water of the primary and secondary circuits in the steam generators travels in contra-flow.

The water of the primary circuit leaves the steam generators at a temperature of about 196 deg. C. and enters the inlet pipe of the main circulation pumps, of which there are four. Three operate at peak power output, giving some 300 tons per hour; the fourth pump is in reserve. From the pressure line of the main pumps, the water enters the input collector of the installation, from which it is fed to the channels.

Feed pumps supply fresh water to the primary circuit, and with the aid of an automatic mechanism feed the water to seals in the main circulation pumps in such a way that the pressure of this water is always 0·5 atmospheres above the water pressure in the pump. This provides a hydraulic seal which prevents the radioactive water in the main pumps from penetrating along the shaft.

### DECOMPOSITION OF WATER

It should be noted that as the water of the primary circuit flows away from the reactor, its activity gradually falls. This activity is due to oxygen activity (0·2 curies per litre) with a short decay period (7 seconds), whereas at the inlet to the reactor the activity of the water (2·10 curies per litre) is due basically to the activity of impurities.

Precautionary measures include compensation for changes in water volume during heating and cooling, a device to maintain the pressure in case of leakage, contact units in the primary-circuit bypass for burning the explosive mixture arising from water decomposition due to neutron irradiation.

Since radioactive contamination of the secondary circuit is unlikely, the secondary circuit is of conventional pattern. The secondary water (the condensate) is fed by feed pumps to the heater of the steam generator; it then enters the evaporator, in which the level is maintained constant by an automatic mechanism, and finally passes to the steam superheater. At peak power output, the three groups of steam generators produce 40 tons of steam per hour at a pressure of 12·5 atmospheres and a temperature of 255 to 260 deg. C. This steam is directed along the main steam line to the turbo-generators and from the turbine condenser the water returns to the steam generators.

During the start-up period, the reactor operates without producing steam; in this case hot water, the heat of which is removed by refrigerators, is delivered by the steam generators.

The station incorporates a variety of ancillary electrical equipment, a central control panel, personnel safeguards and numerous experimental facilities.

### GRAPHITE TEMPERATURE

Since the atomic power station was started up, it has been tested in various operating conditions and has produced about 15 million kWh of electrical energy. There has not been a single case of fuel-element failure. Both water flow through the fuel channels and reactor operation proved stable, and rated power can be maintained for a long period (from loading to loading). The temperature of the graphite was found to be above the rated value and at the hottest points reached 650 to 700 deg. C. Start-up from zero to the rated power takes approximately half an hour and from cold after repairs in one and a half to two hours. The fuel elements are replaced once in two months.

The automatic control system, installed equipment, and warning systems worked without failure, and few cases of cracks and pits arose. However, hydraulic shocks occurred in the steam generators when they were heated during the first start-up times. It became clear later that this was due to steam generation in the water heater and arose from excess heating speed and low steam pressure in the steam generator. There have been no cases of over-irradiation of the staff of the power station.

# ATOMIC ENERGY FOR PEACEFUL PURPOSES

## PRESIDENTIAL ADDRESS TO GENEVA CONFERENCE

*The International Conference on the Peaceful Uses of Atomic Energy opened in the Palais des Nations at Geneva on Monday, August 8, with addresses by M. Max Petitpierre, President of the Swiss Confederation and M. Dag Hammarskjöld, Secretary General of the United Nations Organisation, together with the reading of goodwill messages from the prime ministers of some of the leading participating nations. The meeting continued with the presidential address of Dr. Homi J. Bhabha,* the President of the Conference. In his address Dr. Bhabha spoke of three epochs into which the history of man could be divided, each of which was marked by particular conditions in the supply of energy. The address, which included a reference to the possibility of using the fusion reaction for power production, is reproduced in abridged form below.*

### THREE EPOCHS OF HISTORY

The purpose of this Conference is to discuss the peaceful uses of atomic energy, and to exchange scientific and technical knowledge connected with it. The importance of this aim can hardly be over estimated. Knowledge is perhaps the most important possession of man. It is knowledge and not any notable change in his physical and mental equipment which has enabled him to build the civilisation of to-day. One can hardly foresee the far-reaching development to which this Conference may lead.

In a broad view of human history it is possible to discern three great epochs: one begins with the appearance of early civilisations in the valleys of the Euphrates, Indus and Nile; the second arises with the industrial revolution; and the third opens with the discovery of atomic energy. Each epoch marks a change in the energy pattern of society. Energy is the great prime mover on which our daily life and even existence itself depends; without solar energy, which is ultimately a form of atomic energy, the emergence and continuance of life would not have been possible.

### ENERGY USAGE

In the first epoch all the energy necessary for performing mechanical work of every kind was supplied by muscle, either human or animal; this provided at best half a kilowatt-hour in an eight-hour day—a small figure compared with the 20 killowatt-hours now available per person in industrially advanced countries. In the second epoch following the advent of the industrial revolution increasing use was made of chemical energy to supplement the efforts of muscle so that to-day each man in certain countries has the energy equivalent of 45 slaves and in one country about twice this.

The total consumption of energy has risen in a staggering manner. If Q represents a quantity of energy equal to $10^{18}$ British thermal units corresponding to $33 \times 10^9$ tons of coal, then in the first 18½ centuries since Christ some 9Q units were consumed. In 1850 the rate of consumption per century was Q; by 1950 a further 5Q had been consumed and the rate had risen to 10Q per century.

Population too has recently risen rapidly; less than three hundred million in the first century A.D., it showed no remarkable increase until the middle of the Sixteenth Century, but subsequently it reached 1,500 million in 1900, some 2,000 million in 1930, and roughly 2,300 million in 1950. By the end of the century experts calculate that it will lie between 3,500 and 5,000 million.

The next important figure is the per capita utilisation of energy. In the world as a whole this has increased at a rate of some 2·2 per cent. per annum compounded, while the present rate is about 3 per cent. This must soar enormously when the underdeveloped countries of the world with large populations become industrialised. It is of interest that if the per capita consumption throughout the world were equal to that of the United States, then the rate of Q per decade in 1950 would rise to 5½Q.

This development is likely to depend, however, on the availability of fuels. The concensus of opinion is that the total economically recoverable world reserves of coal, oil, gas and oil shale are equivalent in energy value to less than 100Q, while some put the figure under 40Q. It is probable that, at the rate at which the world consumption of energy is increasing, these reserves will be exhausted in under a century.

### RESERVES OF ATOMIC ENERGY

Thus it is necessary to turn to atomic energy for a solution; this marks the beginning of the third epoch. It has been estimated that the total recoverable world reserves of uranium and thorium contain an amount of energy of the order of 1,700Q, which would be sufficient to enable the underdeveloped countries to reach the standard of living of the industrialised nations; and secondly to maintain a rising standard of living for many decades and possibly for several centuries.

There is no longer any question that atomic energy can be used for power generation. We know that it has been used for several years to heat houses in winter in a small area in the United Kingdom; a United States submarine has successfully used it for propulsion; in the Soviet Union an atomic power station of 5,000 kW (see page 233) has fed electricity into the grid; and an atomic power station of 50,000 kW is expected to be in operation in the United Kingdom next year.

The basic ideas of atomic energy are simple, but its technology is sophisticated and difficult. High-purity materials and the need for remote control are two of the problems. There are also at least six basically different designs, which differ in the physical and chemical state of the fuel, the moderator used, if any, and the method employed for extracting heat. It is on the results of experience with all forms of reactor that the important consideration of economics depends.

Apart from the generation of electric power, atomic energy offers other benefits and problems. The use of fission products is already well known (see ENGINEERING, "Radioactive Isotopes," page 630, vol. 177, and "Atomic 'Waste,'" page 782, vol. 179, June 24, 1955)

* Chairman of the Atomic Energy Commission of India.

but there are also many biological effects of nuclear radiation, both advantageous and unfavourable. Artificially induced mutations have been used to improve the strains of plants or crops. Although many mutations are lethal or deleterious, the evolutionary process of natural selection is enhanced, with the extinction of deleterious carriers and the survival of favourable ones.

### POWER FROM FUSION

Atomic energy also differs from chemical energy in its concentration. The complete combustion of a pound of carbon yields 14,650 British thermal units of energy, while the complete fission of a pound of uranium would yield some $3 \cdot 3 \times 10^9$ British thermal units; or the complete fission of a ton of uranium or thorium would give approximately as much energy as 2½ to 3 million tons of coal.

However, the application of the fission process may one day be regarded as the primitive period of the atomic age. If the fusion process as used in the H-bomb can be controlled satisfactorily and the formidable technical problems solved—and there is no scientific knowledge available to-day which denies this possibility—it may well become the source of the future. When this happens, the energy problems of the world will truly have been solved for ever, for the fuel will be as plentiful as the heavy hydrogen in the oceans. I venture to predict that a method of liberating fusion energy in a controlled manner will be found within the next two decades. After all, it is not yet 15 years since atomic energy was released in an atomic pile by Fermi. (Dr. Bhabha also paid tributes to Dr. Albert Einstein and Lord Rutherford.)

All the basic discoveries out of which atomic energy arose were made before the second World War by scientists of many nations working in free and full collaboration. Since the war most of the technical developments in this field have been made by a few nations, each working in isolation and secrecy. If so much has been achieved by efforts in a few countries, how much more could be achieved by the combined effort of all. I hope this Conference will play its part in helping the progress of mankind towards the ever-widening dawn of the atomic age, with the promise of a life fuller and happier than anything we can visualise to-day.

# EXPERIMENTAL FACILITIES OF E.443 REACTOR

## PROVIDING HIGH NEUTRON FLUXES

*In a paper given at the International Conference on the Peaceful Uses of Atomic Energy, Mr. H. J. Grout and Mr. F. W. Fenning, of the Atomic Energy Research Establishment, Harwell, discussed the experimental plant E.443. The plant was made within certain design limits to give greater neutron fluxes than previously obtainable. Three general types of facility are provided: beams of neutrons; irradiations without close control; irradiations with close control of environment. The paper gives a general description of the reactor, external facilities attached to the reactor, and a table of experimental facilities.*

With the existing facilities at Harwell it is not possible to achieve neutron fluxes greater than $1 \cdot 5 \times 10^{12}$ thermal neutrons per square centimetre per second. Many aspects of nuclear reactor development and the need for radioisotopes of higher specific activity called for considerably higher neutron fluxes for experimental purposes.

Several possible types of experimental reactor were therefore considered, the final choice being a heavy water cooled and moderated reactor with nearly pure U235 fuel. The two general considerations leading to this decision are contradictory in some respects, namely, the need to limit the heat to be disposed of at a given neutron flux level, and the desirability of spreading the neutron flux achieved over as large a volume as possible.

The objectives finally agreed upon were:—

(i) that the reactor should make available thermal neutron fluxes up to $10^{14}$ neutrons per square centimetre per second;

(ii) that the reactor should be capable of producing the equivalent of 30,000 curies per annum of cobalt 60 at high specific activity;

(iii) that the reactor should be capable of maintaining a limited number of loops for testing fuel systems for advanced types of reactor;

(iv) that the reactor should cost no more than £2 million including site development, adjacent laboratories and offices and heavy water.

### WHAT EXPERIMENTERS NEED

Experience with BEPO indicates the need for three general types of facility. These are:—

(i) *Beams of neutrons.*—These require some collimation in the shield, a means of cutting off the beam without shutting down the pile, space adjoining the reactor face. Examples of this type of requirement envisaged for E.443 are a high speed chopper type monochromator used in conjunction with a 50 m. flight path and a crystal spectrometer. The holes intended for such purposes are horizontal, the shield holes opening out to large diameter half-way through the biological shield, thereby giving space in which to fit a collimator fitted with a suitable shutter.

(ii) *Irradiations without close control.*—These are the simplest requirements to fulfil. Included in this category is the preparation of radioisotopes where the parent material is stable in the temperature and radiation conditions available. For this purpose small diameter vertical holes and some horizontal holes are available. Their design is simple, providing only for small heat production in the irradiated specimen. This heat is removed by the reactor cooling circuits without special provision. No permanent allocation of space in the reactor building is required, but a shielded container is required for periodic discharge of irradiated material.

(iii) *Irradiations in which close control of environment is required.*—These are by far the most difficult facilities to supply and operate. They include the use of holes for solid state studies, radiation chemistry studies and experimental fuel element testing. They usually require control of temperature or neutron spectrum thereby necessitating special heat removal circuits or furnaces and considerable space adjacent to the reactor for control and recording instruments. Usually the reliability of such experimental work must be as good as the reliability of the reactor itself. Clearly the maximum possible space inside the reactor and easiest access from outside the shield are desirable. In attempting to achieve these in E.443 as many large diameter vertical holes as possible have been planned and have been made removable. Limitations referred to later have restricted the number of holes accessible to both ends and these are horizontal. Provision is made for up to 1 MW of heat to be disposable from all these facilities.

The location at Harwell imposes requirements of safety which it was decided to meet by containing the reactor within a steel pressure type building. This reacts back on experimental facilities through the cost of extra space inside such a building. Thus an early requirement for some vertical holes to pass right through the reactor and be accessible at both ends was finally abandoned because of the additional cost.

Other limitations on experimental facilities arise from the reactivity required to operate with them and the need for control devices to cover the variation in reactivity during operation. Here again, flexibility has been sought so that many facilities requiring large reactivity are optional and when conditions are favourable absorber control plates can be replaced by experimental holes.

### GENERAL DESCRIPTION OF REACTOR

The reactor core consists of up to 2·5 kgm. of U235 in the form of uranium-aluminium alloy plates arranged in boxes to form an approximate cylinder of length 60 cm. and equivalent diameter 86 cm. This cylinder is in the centre of a cylindrical aluminium tank 2m. in diameter and 2m. in height. The elements are cooled by forced upward flow of $D_2O$ which overflows the top of the elements to become the reflector before passing out to a heat exchanger for cooling and recirculating. Outside the aluminium tank is a graphite reflector of 60 cm. thickness on the sides and bottom. The graphite is in turn contained in a steel tank which is helium filled. Outside this tank is a biological shield of concrete except for a 1·5 m. square section occupied by a thermal column with appropriate shielding at the outside.

Below the reactor is a plant room containing pumps and a heat exchanger for the $D_2O$. The total heat removal catered for is 10 MW from the core, 1 MW from all experimental facilities, which consist of aluminium tubes entering graphite or $D_2O$ vertically or horizontally, details being given in the table below.

Owing to the need for containment the space available within the reactor hall is extremely limited, and therefore additional facilities have been provided adjacent to the main entrances. An open building 106 ft. long by 33 ft. wide and provided with a 20-ton crane, changing room and extensive services for power, light, ventilation and the disposal of active effluents will be used for the examination of irradiated material. A deep pond sunk in the floor will allow of under-water examinations and also the dismantling of activated equipment.

Remote controlled power heads in shielded rooms will be installed to facilitate the dismantling of both active and contaminated equipment in preparation for detailed examination.

The table indicates all the facilities which can be made available, though not necessarily all at once. Included in the table are estimates of the reactivity loss associated with the installation of particular holes, but of course the inclusion of equipment in those holes may add to or subtract from this. The flux figure quoted is the maximum thermal flux available in the facility before any equipment is installed in it.

*Facilities of E.443*

| General Description | Dimensions | No. | Reactivity loss due to empty facility (per cent.) | Maximum thermal flux in empty facility n/cm.²/sec. |
|---|---|---|---|---|
| Fixed horizontal round tubes: | | | | |
| (*a*) Entering $D_2O$ reflector | 10 in. dia. | 1 | 0·5 | $8 \times 10^{13}$ |
| | 6 in. dia. | 1 | 0·2 | $8 \times 10^{13}$ |
| | 4 in. dia. | 6 | 0·6 | $7 \times 10^{13}$ |
| (*b*) entering graphite reflector only | 6 in. dia. | 10 | | $1 \cdot 5 \times 10^{13}$ |
| Fixed, horizontal oval tube passing right through $D_2O$ reflector | 4 in. by 2 in. | 1 | 0·4 | $8 \times 10^{13}$ |
| Removable, vertical round tubes: | | | | |
| (*a*) entering $D_2O$ reflector | 6 in. dia. | 4 | 0·8 | $8 \times 10^{13}$ |
| | 4 in. dia. | 5 | 1·2 | $5 \times 10^{13}$ |
| | 2 in. dia. | 9 | 0·5 | $9 \times 10^{13}$ |
| (*b*) entering graphite reflector only | 6 in. dia. | 6 | | $0 \cdot 4 \times 10^{13}$ |
| | 4 in. dia. | 2 | | $0 \cdot 4 \times 10^{13}$ |
| | 10 in. dia. | 2 | | $0 \cdot 4 \times 10^{13}$ |
| Fixed horizontal rectangular tube passing right through bottom graphite reflector | 8 in. by 12 in. | 2 | | $1 \times 10^{13}$ $1 \times 10^{13}$ |
| Thermal column of graphite containing square holes | 5 ft. by 5 ft. | 1 | | $10^{11}$ |
| | 4 in. by 4 in. | 9 | | $10^{11}$ |

# PROGRESS IN ASTRONAUTICS

## DEVELOPMENTS ANNOUNCED AT COPENHAGEN CONGRESS

The Sixth International Astronautical Congress was held in Copenhagen from August 1 to August 6. It was thrown into unusual prominence by the announcement by President Eisenhower, on the Friday before its opening, of the existence of an American artificial satellite project and by the later statement of the Russian Government that they too had similar plans.

About 150 representatives of the 18 member societies were present together with observers from new societies being formed in Belgium and France and from the Soviet Inter-Departmental Commission for Co-ordinating Research into Interplanetary Communication. Although the Russians have been invited to attend earlier Congresses this is the first time that they have sent representatives.

The first two days were devoted to business sessions of the International Astronautical Federation. One new member, the Sociedad Interplanetaria Chilena (Chile) was elected; this brought the total number of member societies to 19, representing 18 countries and about 9,000 individuals. The President, Mr. Frederick E. Durant (American Rocket Society) and one Vice-President, Professor T. M. Tabanera (Asociacion Argentina Interplanetaria) were re-elected. As the Congress in 1956 is to be held in Rome, the President of the Associazione Italiana Razzi, Professor General G. A. Crocco, was elected second vice-president of the Federation. The 1957 Congress will be held in Spain and in private discussions the Russian observers said that they thought it would be possible to hold the 1958 Congress in Moscow.

Two major projects had been worked on by various committees during the past year. The first of these was the proceedings of the Federation—" Astronautica Acta." Publication had commenced early in 1955. The proceedings of the 1954 Congress, which was held in Innsbruc, had also been published.

A *Glossary of Astronautical Terms*, in English, French, German and Italian, had been completed and printed and would very shortly be issued.

At the opening of the Congress a cable was sent to President Eisenhower congratulating him on the U.S. government's policy in initiating an artificial satellite project. Particular appreciation was expressed in that the project was a peaceful one intended for development in time for the International Geophysical Year (July 1, 1957, to December 31, 1958). The full co-operation of the I.A.E. in any possible way was offered. In a reply received later in the week it was said that the Federation's offer was being considered.

### SATELLITES AND SATELLOIDS

Of the 19 papers read at the congress, six were directly concerned with the artificial satellite, which is indicative of the importance attached to this project by members of the Federation. Although it is stated that the satellite announced by the U.S. government will circle at a height between 200 and 300 miles, there is in general a much greater interest in information about the upper layers of the atmosphere lying between 60 and 90 miles. The first paper of the technical sessions dealt mainly with the means for examining this region. It was entitled " The Satelloid," and presented by Mr. Kraft A. Ehricke, a former V.2 worker now with the American firm Convair. Although a true satellite operated outside the effective atmosphere and would remain indefinitely in a permanent orbit, a satelloid was defined as a vehicle operating in an orbit at an altitude where a small amount of residual drag would be experienced. A certain amount of thrust would therefore be required in order to maintain the vehicle in equilibrium. Although much work could undoubtedly be carried out with small instrumented satellites, a man-carrying satelloid would prove of great benefit. A man was the highest and most versatile piece of equipment available and was indeed essential for certain experiments. It would also be necessary, before stepping out into space with man-carrying space-ships, to perfect the techniques of returning to earth. Mr. Ehricke therefore concentrated on man-carrying satelloids.

One of the problems of sending a vehicle into the atmosphere was that of changing from initial to aerodynamic flight. The rate of change of lift coefficient with angle of attack for wings at the altitudes and speeds (about 18,000 m.p.h.) under consideration was small, and thus control would be sluggish. It would be necessary to use jet attitude control to produce a high angle of attack and hence the high values of lift and induced drag required to slow the body down. The temperature rise due to compression heating would doubtless be a difficult one but it should be able to overcome it with correct flight programming.

The amounts of propellant to keep a satelloid of 10,000 lb. empty weight in its orbit varied very rapidly over a small altitude range. Using a propellant mixture with a specific thrust of 250, which was within the capabilities of modern propellants, a satelloid at 60 miles altitude would require 1,500 lb. of propellant per revolution of the earth and one at 100 miles altitude would require 3 lb. per revolution. It would appear then that an economic operating altitude for a satelloid would be 80 to 120 miles.

Looking further into the future the speaker foresaw the application of satelloids to the investigation of the surface of Venus. Although the easiest planet to reach, Venus was completely covered by cloud and no break in it has ever been observed. Several widely differing hypotheses concerning the surface conditions had been postulated but observational data were required before any landing could be contemplated. A space-ship placed in an orbit could send satelloids down into the atmosphere to receive telemetered data on the surface conditions.

Several papers considered the problems involved in placing a satellite in its orbit. Mr. Derek Lawden, senior lecturer in mathematics at the College of Technology, Birmingham, in his paper " Optimum Launching of a Rocket into an Orbit About the Earth," obtained the following results. The step-rocket carrying the satellite was assumed to be launched from a point situated on the equator in a west-east direction. It should be noted that this method enabled the component of the earth's rotational speed to be used although the recently-announced American satellite was said to be intended for a circumpolar orbit.

For maximum economy the step-rocket should be fired vertically until it was outside the thickest of the atmosphere (20 to 40 miles) and then slowly tilted until its path was approximately parallel to the earth's surface. When the vehicle had acquired sufficient momentum to carry it out to the level of the orbit the rocket motor would be shut off and the vehicle would coast along an elliptical arc until it intersected the final orbit. At this point a relatively short burst from the motor (about 120 seconds) would cause an increase in the rocket's velocity sufficient to affect its transfer into the circular orbit.

During the first phase of vertical ascent the method of propellant consumption to produce the greatest economy would be determined by a compromise between two opposing factors. These were the need to reduce speed in order to reduce losses due to air drag and the need to expend propellant rapidly so that energy was not wasted in transporting the propellant to a great height. In a small rocket (say 1 ton at launching) the first of these factors was important and the thrust and hence the propellant expenditure could be so programmed as to produce a minimum consumption. With a large rocket (say, 1,000 tons), on the other hand, the air resistance was negligible. Thus the structural strength determined the allowable acceleration and in such a case there was no possibility of achieving the optimum thrust programme.

The more detailed problem of converting a slightly elliptical orbit into a circular orbit was dealt with by Dr. A. Boni (Associazione Italiana Razzi) in a paper entitled " Artificial Satellite—Orbit Synchronising System." Dr. Boni showed that to produce a circular orbit it would be necessary to measure the actual angular velocity of the satellite. By applying a thrust at right-angles to the radius joining the satellite to the terrestrial centre of gravity and proportional to the difference between the actual angular velocity and that required for a circular orbit, the satellite would be forced into the circular orbit. It was important to stop thrusting as soon as the correct angular velocity was reached, otherwise a long-period instability would appear.

In " Temperaturprobleme in der Astronautik " Mr. L. Hansen (Dansk Interplanetarisk Selskrab) dealt with the variation of temperature that would be undergone by a small instrument carrying satellite of about 110 lb. wt. On the ascent, the maximum skin temperature reached would be 1,200 deg. C. but because of the very short time during which this occurred the temperature inside would rise only to 100 deg. C. When the satellite was in its orbit the temperature would rise to 110 deg. C. on the day side of earth and fall to − 120 deg. C. on the night side. If the interior of the hull were sufficiently well insulated it would maintain a temperature around the average of − 4 deg. C. It was pointed out that, although these temperatures were only approximate existing materials and instrument techniques were sufficiently advanced to deal with them.

### TRACKING THE SATELLITE

Having established a small instrument-carrying artificial satellite it will be necessary to track it. Radar methods using a transponder in the vehicle will doubtless be of great use but optical methods still give the greatest accuracy. Mr. R. Tousey, of the U.S. Naval Research Laboratory, in his paper " The Visibility of an Earth Satellite " assumed the satellite to be a sphere 21 in. in diameter, travelling in the plane of the equator at altitudes varying from 200 to 800 miles. Illumination was provided only by the sun. If one knew exactly where and when to look when nearly directly overhead at 200 miles altitude it would first be visible through 7 × 50 binoculars when the sun was 2 deg. below the horizon. It would be visible to the naked eye for angles of greater than 9 deg. as long as it was illuminated by the sun. The satellite would cross the field of view in 5 seconds and so a close watch would need to be maintained. It was suggested that a battery of such binoculars in fixed positions be used for visual observations. There would probably be several stars in the field of vision as bright as the satellite and a few brighter. Movement of the satellite would be conspicuous by comparison.

For altitudes greater than 200 miles the satellite would be more difficult to see because of the reduction in brightness due to the inverse square law. As a compensation, the satellite would be illuminated for a longer time and thus the sky would be blacker during the latter part of the viewing. Also the higher the vehicle the slower it will appear to move; at 800 miles it could cross the field of view of 7 × 50 binoculars in 21 seconds. It was strongly recommended that observations be made from as high a point as possible to eliminate the effect of haze.

One of the possible hazards to be faced on returning a space-vessel to earth is that of encountering " bumps," not in the lower atmosphere but at heights of 30 to 50 miles. The evidence for this was examined by Dr. A. E. Slater (British Interplanetary Society) in his paper, " Turbulence Above the Ozone Layer." At a height of about 30 miles there exists a layer

of ozone which, because of absorption of solar ultra-violet radiation becomes quite hot. This might produce turbulent conditions in the layers above it. The majority of the available evidence was from sounding rockets and meteor trails. Meteor trails became zigzag in formation very soon after they were produced, which indicated turbulence but rocket results, on the other hand, were contradictory; the weight of the evidence pointed to a turbulent layer—although much more investigation was needed before this was a certainty. But even if such conditions existed the speed of the vertical currents would need to be considerable, perhaps about 500 ft. per second before it could be effective. The reason for this is that a bump is caused by the increase of wing incidence due to passing through the up-current. Since the flight speed is high (over 10,000 m.p.h.) an up-current to have any effect must also have a high velocity. For an up-current to reach a speed of 300 ft. per second after rising from 30 to 50 miles it would have to be 10 deg. C. hotter than its surroundings. In the present state of knowledge of this region it was difficult to venture an opinion on the possibility of this occurring.

### PHYSIOLOGY IN SPACE

The design of cabins for man-carrying space-flight will need very careful consideration and some of the problems were dealt with by Mr. Fred A. Hitchcock of the Laboratory of Aviation Physiology, Ohio State University, in his paper, "Some Considerations in Regard to the Physiology of Space Flight" and by Professor S. F. Singer in "Cosmic Ray Effects on Matter at High Altitudes." Mr. Hitchcock said that space conditions from the point of view of providing a sealed respirable atmosphere, started quite low down in the atmosphere. At 63,000 ft. the total barometric pressure was approximately 47 mm. Hg. which was the vapour pressure of the blood and body fluids at the normal body temperature. At any altitude above this, therefore, a fully pressurised cabin must be provided. Up to about 90,000 to 100,000 ft., however, oxygen could be provided through a mask and the body pressurising gas could be supplied by compressing the ambient atmosphere. Above this altitude a fully-sealed cabin would be needed and in this respect all higher flights would be effectively space-flights. Work was already in progress at Ohio State University to produce a sealed cabin using a simple air conditioning system in which the cabin air would be periodically passed through a container of liquid oxygen. The carbon dioxide and water vapour would be frozen out and the atmosphere continually enriched.

This system should be suitable for flights lasting as long as several days but for longer periods a closed cycle in which the oxygen would be regenerated from the carbon dioxide would be essential. This method would consist of the establishment of a balance between the human occupants and some form of plant life. It seemed likely that the most suitable plants would be a species of chlorella algae. Some of these organisms were extremely efficient photo-synthetically and experimental work with them was already under way.

The tolerance of living animals to a vacuum would also be of great importance in emergency and studies of this topic were proceeding at Ohio. Experiments had shown that immediately following exposure to a pressure of 30 mm. Hg. or less respiration became deep and rapid. This condition lasted for a few seconds and at the same time there was a marked abdominal distension due to expansion of gases present in the body. The animal collapsed in about 8 seconds, mild convulsions occurred for a further 10 to 12 seconds and after that was quiescent. Thirty to 40 seconds after reduction of pressure, secondary body swellings occurred due to boiling of the body fluids. Recovery was usually complete if the exposure to low pressure was less than 90 seconds but almost always fatal if over 2 minutes.

One of the major open questions in space medicine, the effect on living tissue of heavy primary cosmic rays, was discussed by Professor S. F. Singer. Of the two possible effects, atomic and nuclear, the former was the more likely to cause serious trouble. The major atomic effect was that of ionisation. It had been shown that the heavy particles, which consisted of nuclei of atomic weights up to that of iron, could produce very dense ionisation trails which could actually destroy living cells. The nuclear effect, that of the transmutation of nuclei, was permanent and therefore cumulative. In all cases, however, it appeared that this would be less important than the ionisation. Should the number of heavy primaries in outer space prove to be too great for safety then some form of protection would be needed. The effect of the shielding material would be to interact on a nuclear level with the incoming heavy primaries breaking them down into lighter nuclei with much lower ionising power. It was shown that hydrogen itself would give the most effective shield on a weight basis.

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## BOOKS RECEIVED

*Some of the books noticed here are selected for extended review in* ENGINEERING.

**Aslib Aeronautical Group Classification Conference.** The following papers presented at the Conference may be obtained from *P. S. Walkins, c/o The Library, British European Airways Engineering Base, London Airport, Hounslow, Middlesex:—*

Subject Analysis in 81 Concepts, by E. G. Brisch; General Decimal Classification Systems for Aeronautical Use, by G. Scherpenhuijsen Rom; The Psychology of Classification, by J. E. L. Farradane; The Function of Classification in Information Retrieval, by C. Cleverdon; Test of N.L.L. Card Catalogue of Aerodynamic Measurements, by H. F. Vessey; Essentials for Document Retrieval, by R. A. Fairthorne; The Efficiency of Subject Catalogues, and the Cost of Information Searches, by R. G. Thorne.

**CABMA Register of British Products and Canadian Distributors, 1955-56.** Published jointly by *Kelly's Directories, Limited*, 186 *Strand, London, W.C.*2., and *Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.*1. (42*s.*)

This is the third edition of the register of the Canadian Association of British Manufacturers and Agencies. The buyers' guide provides an alphabetical list of some 4,000 British products available to the Canadian market, with their suppliers given under each heading. The French equivalents of these headings are set out in alphabetical order in a separate glossary. A directory of over 4,500 British firms gives details of their distribution arrangements in Canada, and these arrangements involve about 2,750 Canadian companies, some of whom supply further information in another section. Special sections enable the Canadian buyer to identify products and their sources of supply when only their proprietary names or trade marks are known. The six sections are divided for easy reference by index cards, and contain instructions in French as well as English.

**Thermionic Valves, 1904-1954: The First Fifty Years.** *The Institution of Electrical Engineers, Savoy-place, London, W.C.*2. (9*s.*; 4*s.* to members.)

This is a reprint of the lectures delivered by Sir Edward Appleton, Professor G. W. O. Howe and Dr. J. Thomson before the Institution of Electrical Engineers in November, 1954, to celebrate the invention by Dr. J. A. Fleming of the diode 50 years earlier. It also contains the address of the Lord President of the Council (the Most Hon. the Marquess of Salisbury) on the same occasion, an appreciation of Fleming and de Forest by Captain C. F. Booth, and a reproduction of Fleming's British Patent Specification No. 24,850 of 1904. An illustrated catalogue of the thermionic valves exhibited at the Institution during the celebration is included.

**100 Years of Aluminium as an Engineering Material.** *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.*2. (4*s.* 6*d.*)

Reprinted from *The Engineers' Digest* for May, 1955, this pamphlet of 48 pages contains nine articles by leading metallurgical authorities, namely, "The History and Development of Aluminium and its Alloys," by Professor A. von Zeerleder; "British Standards for Aluminium by E. Elliott; "The Welding of Aluminium and its Alloys," by J. F. Lancaster; "Joining Aluminium by Soft Soldering," by H. C. Watkins; "The Metallurgical Control of High-Quality Aluminium Forgings," by T. E. Murch; "Die Casting in Aluminium," by Frank G. Woollard; "Finishes for Aluminium," by A. W. Brace; "Aluminium-Alloy Bearings," by E. A. G. Liddiard; and "The Liability to Fatigue Failure of Aluminium-Alloy Structures," by Tibor Haas.

**Guide to the Coalfields, 1955.** Edited by R. H. WALKERDINE. *The Colliery Guardian Company, Limited*, 30 *and* 31 *Furnival-street, Holborn, London, E.C.*4. (20*s.*)

The greater part of this volume consists of descriptions of deep mines operated by the National Coal Board or under licence from the Board. Subdivided in terms of the Divisions and Districts of the Board, the *Guide* gives such details as the address and telephone number of each mine, names of officials, mineral extracted and an indication of the suitability of the coal for differing purposes—e.g., coking, household or steam, etc. A series of maps, at a scale of 1 inch to 1 mile, is arranged in groups representing the appropriate Divisions; key maps for each Division relate the local maps. A large number of advertisements and a buyer's guide for the industry are also contained in the *Guide*.

**Defects in Crystalline Solids.** Report of the Conference held at the H. H. Wills Physical Laboratory, University of Bristol, July, 1954. *The Physical Society*, 1 *Lowther-gardens, Prince Consort-road, London, S.W.*7. (40*s.*)

The 47 papers printed in this report were presented at a conference organised, under the chairmanship of Professor N. F. Mott, F.R.S., by the University of Bristol, in co-operation with the International Union of Physics, the Institute of Physics, and the Physical Society. The papers deal mainly with defects in solids, especially dislocations and point defects and with some of the new experimental methods of investigation such as the magnetic resonance methods.

**Modern Surveying for Civil Engineers.** By HAROLD FRANK BIRCHAL. Second edition revised. *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (50*s.*)

The number of books being currently published on surveying is extraordinarily high, reflecting the importance of the subject to a large group of engineers and the belief in the future growth of large-scale construction in public works. Like all books on the subject, Mr. Birchal's volume describes the instruments used and discusses the mathematics involved, but special emphasis is laid on the preparation and making of extensive surveys, such as are required for railways, roads and harbour works in the, at present, under-developed territories.

**Water Supply Engineering.** By HAROLD E. BABITT and JAMES J. DOLAND. Fifth edition. *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (61*s.*)

This book is a standard reference work on water-supply engineering. It covers public, private and industrial water supplies, and discusses all the information required for the complete design of waterworks. The scope of the book begins with the inception of the project, its design and construction, maintenance and operation, including notes on many methods of water purification now practised. Financial and administrative principles are described. Bases for the estimation of water usage are explained; methods of determining rainfall, surface run-off, etc., are described. Full treatment is also given of both the civil and mechanical design problems likely to be met.

**The Life of Lord Nuffield: A Study in Enterprise and Benevolence.** By P. W. S. ANDREWS and ELIZABETH BRUNNER. *Basil Blackwell*, 49 *Broad-street, Oxford.* (25*s.*) (Reviewed on page 201, in the issue of August 12.)

**Reference Tables for Thermocouples.** By HENRY SHENKER, JOHN I. LAURITZEN, JR., ROBERT J. CORRUCCINI and S. T. LONBERGER. National Bureau of Standards Circular 561. *The Superintendent of Documents, U.S. Government Printing Office, Washington* 25, *D.C., U.S.A.* (50 cents.)

The present reference tables have been prepared to make available, in convenient form, the data previously issued in publications of the United States National Bureau of Standards, now out of print. They enable the measured electromotive force of thermocouples, in absolute millivolts, to be converted into equivalent temperatures in degrees Centigrade or Fahrenheit. Both the platinum-metals and the base-metals thermocouples are covered.

## BRITISH STANDARDS

*The following publications have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 2 Park-street, London, W.1, at the price given after each title.*

**Flexible Polyvinyl Chloride (P.V.C.) Extrusion Compounds.** (5*s.*, *post free.*)

A new standard, B.S. 2571, covers three classes of polyvinyl extrusion compounds namely, Class 1, compounds with specified electrical properties and having a volume resistivity of not less than $10^{13}$ ohm-cm. at 23 deg. C.; Class 2, compounds with specified electrical properties and having a volume resistivity of not less than $5 \times 10^{8}$ ohm-cm. at 23 deg. C.; and Class 3, compounds for which the electrical properties are not specified. Each of these classes is further sub-divided into types in such a manner that, in all, 12 types of compounds are provided for. The specification stipulates requirements for the composition, form and appearance of the compounds, together with limits for a number of mechanical, physical and other properties. Methods of test are given in appendices.

**Zinc and Zinc Alloys for Die Casting.** (3*s.*, post free.)

Two specifications issued under one and the same cover, B.S. 1003 and 1004, and dealing respectively with high-purity zinc (1003) and zinc alloys for die casting and zinc-alloy die castings (1004), have now been published in revised form. They were first issued in 1942. The alloys covered are based on the result of much research and the chemical composition chosen were those giving the optimum balance of properties. Since subsequent experience has shown that some allowance should be made for the loss of aluminium and magnesium during casting, the limits of these two elements have been slightly modified in the present revision.

Various impurities are strictly limited in the basic zinc used for the manufacture of the alloys and limits have also been imposed for other elements included in the previous edition under the heading "Traces."

**Components of Crawler Tractors and Earth-Moving Equipment.** (4*s.*, post free.)

A new specification, B.S. 2596, which relates to components of crawler tractors and earth-moving equipment, is divided into two parts. Part 1 is intended primarily for crawler-type tractors for industrial use. It includes features covering the mounting of equipment such as cable-control units and heavy-duty winches; the classification of three classes of tractors; requirements for power take off and tractor drawbars; and a method for describing the tractor gauge and the width of track plates.

Part 2 deals with scrapers and dozers and specifies requirements for cutting edges, cable wedges, wire ropes and other features. For the scraper, a method of determining size and yardage rating and a method of calculating dig and depth of spread are included. For the dozer, definitions are given for side-casting angle, tilt and pitch.

The specification does not aim to standardise design or to restrict development. It specifies those requirements which will secure a measure of interchangeability, where this is necessary; gives definitions where required to avoid ambiguity and specifies standard methods of rating equipment.

The standard recommends that manufacturers should adopt the Unified screw thread and hexagons on all future designs.

**Spot Welding Electrodes.** (3*s.*, post free.)

A revision of B.S. 807, which deals with spot-welding electrodes has recently been published. The first edition, issued in August, 1938, related only to the shanks of spot-welding electrodes and was intended to ensure the interchangeability of electrodes in the sockets of electrode holders. The present edition covers the standardisation of the electrode tips, with particular reference to the relationship between the welding surface and the holder.

Electrodes of the vertical centre, vertical off-set, angle off-set and crank off-set types are dealt with.

**Metal Crates for Milk Bottles.** (2*s.*, post free.)

A new specification, B.S. 2611, deals primarily with the dimensions of crates made either of metal-strip sections, or of wire, to hold 20 one-pint milk bottles (in five rows of four), or 12 one-quart bottles (in three rows of four). Crates complying with this standard will be "interstackable" and the dimensions have been selected so that the crates will be interstackable with a large number of existing types in present use. Due consideration has been given to the dimensions of the bottle pockets in the crates in relation to the sizes of milk bottles specified in a standard, now in course of preparation.

## *Book Reviews*

# FOR THE PROCESS CONTROL ENGINEER

**An Introduction to Process Control System Design.** By A. J. YOUNG. *Longmans, Green and Company, Limited, 6 and 7 Clifford-street, London, W.1.* (42*s.*)

Since 1946 Mr. A. J. Young has been in charge of the Central Instrument Section set up by Imperial Chemical Industries to conduct research into the long-term problems arising from the increasing importance of automatic instrumentation and control in the process industries. To a large extent his book, which has been eagerly awaited for some years now, reports the fruits of the work done by this group. But not only does it make generally available for the first time much recent work which has appeared previously only in papers, it also gives a thorough introductory background in a form likely to appeal to the practising process-control engineer; this is far from true of previous texts in the field, which have been less successful in combining the empirical approach with analysis that is sufficiently advanced to be valuable.

In a pair of very interesting introductory sections, the author discusses the necessity for automatic controls and the status of both experimental and theoretical work in their design; he then considers how economic considerations govern the use and design of control systems, finally stating that "much more advantage could be taken of existing automatic control equipment and technique to improve production efficiency. The future development of control system design depends on the progress made with theoretical and experimental analysis of plant characteristics."

This conclusion leads naturally to a discussion of the response of typical plant to disturbances, which may either be sudden or fluctuate at constant frequency. It is shown how, for the purposes of analysis, practical plants may be considered to consist of a number of transfer stages, whose individual responses are combined. Since the physical meaning of the *frequency response* is readily understood and the individual effects of the component transfer stages are easily combined, this is the approach adopted throughout. To analyse the behaviour of a plant under control it is also necessary to know the frequency response of the controller; and it is next shown how this can be determined for various idealised types of controller with proportional, integral and derivative actions. In the following chapter a graphical method is given for choosing the correct controller settings, to obtain from a controlled plant the behaviour which is desired.

The next four chapters are devoted to more detailed examination of the response of practical controllers and the various other components for measurement and transmission which form part of the control system. This theoretical analysis of controllers typical of those now on the market is a most valuable feature of the book and brings together much information not otherwise readily available. The characteristics of practical plant and of hydraulic valves are then considered.

This is followed by a chapter on control systems that are more complex than the simple single loop so far discussed; these systems involve the use of controllers in cascade, of ratio and averaging control, and of disturbance feedback. The final chapter outlines a technique for control system design and suggests how plant may be modified to improve its controllability. Some of the material in these chapters is controversial, but none the less valuable.

There are several appendices: one gives a mathematical analysis of the response of a stage with distributed parameters, another explains a method for adjusting the settings of a controller when it is being fitted to a plant of unknown frequency response, and the last is a peep into the future entitled "Notes on the automatic factory," in which the author discusses the problems which will be involved in the operation of a "master controller" for a complete process.

This book, with its excellent balance between theory and practice, will be welcomed by all students of chemical engineering and contains material of great interest to all engineers concerned with automatic process control.

★ ★ ★

**The Chain Testers' Handbook.** By C. H. A. MCCAULLY. *Chain Testers' Association of Great Britain, Cunard House, 88 Leadenhall-street, London, E.C.3.* (25*s.*)

Chains are used in every branch of industry and though in comparison with the rest of the equipment needed in a factory they may appear insignificant, they have an importance which is out of all proportion to their number. Obviously the most critical position in which a chain can be used is when it is employed for lifting purposes, and the law recognises the importance of such chains by means of various Acts of Parliament and Regulations controlling their use and testing. The conditions under which a chain may be used, according to the appropriate legislation, are the concern of the factory engineer or management, but the testing and certification of chains is the work of a relatively small body of specialists. Chain testing, like chain manufacture, is ill-served by technical literature, and this book sets out to remedy that defect as far as possible in a single volume of reasonable size.

Standards exist for sizes and safe working loads and for testing procedure, and they are easily obtainable, but among other points the Factories Acts require that chains and lifting tackle shall be examined and tested by "a competent person." The Chain Testers' Association has defined a competent person as ". . . one who has the requisite knowledge and experience, both theoretical and practical, of the type of material under examination to certify with confidence whether it is free from patent defect and suitable in every way for the duty for which the article is required." To help a chain and lifting tackle examiner to reach the required standard the book deals not only with the work which he will normally be called upon to do, but reviews many of the processes which, though he will not as a rule see them, nevertheless have an important bearing on the safety and suitability of the material being examined and tested. Starting with the definition quoted, which is enlarged upon, the book proceeds to short dissertations on the materials used and the methods of manufacture, and then deals with heat treatment, testing, proof testing, examination, and the law relating to lifting tackle. Wire and hemp ropes are the subject of a separate chapter. Proof, safe and working loads are set out in tabular form in a number of appendices.

The book is written expressly for the chain tester and examiner—the man at the bench—and it does not assume that its readers will possess a great deal of technical knowledge. Simplicity is its keynote throughout, and to ensure that it will be self-contained there are short but adequate descriptions of processes and explanations of technical terms such as stress and strain. Some of the processes described briefly, such as iron and steel manufacture, are of course covered very fully in other books, and a short bibliography makes suggestions for further reading in this connection. Other processes, chain making in particular, are neglected by technical

literature, and in this respect the book provides some useful information. A chain may be faulty, and therefore potentially dangerous, because the material from which it was made is not up to specification, because it was badly made, or because it has been ill-treated. Faults introduced during manufacture are usually fairly easy to detect visually, and if a tester and examiner knows how a chain or other piece of lifting tackle is made, he will be better equipped to find the faults.

The user of chains and lifting tackle will find it profitable to read at least some parts of the book. Lifting tackle of all kinds is, and indeed must be, made to a high standard, and if treated correctly will give long and satisfactory service. It will also, to the experienced eye, often give warning that all is not as it should be, and a user of chain can benefit from a knowledge of some of the finer points in the art of examination and testing.

The arrangement of the book is straightforward and it is well illustrated. The text is simple and to the point, but it would have been improved by a more logical use of capital letters. The glossary is too short; it should define words which are peculiar to the trade, or which have a special significance in it. The inclusion of such words as "ore" and "reaction (chemical)" in a glossary of only 24 entries is unnecessary. It would have been better to have defined such words as "dolly," which has a particular meaning in the chain trade. This word is, incidentally, defined in the text, but it is not included in the index or the glossary.

★ ★ ★

## TRAINING MANAGERS FOR THE IRON AND STEEL INDUSTRY

A report prepared by a sub-committee of the Training Committee of the British Iron and Steel Federation deals with training and education for management in the industry. It is a comprehensive review of the methods advised for the education and training of potential managers and of the facilities available in universities and technical colleges. In the past the training which managers received was mostly technical, but the report points out that changes in the educational system, in the size and complexity of processes, in the number of specialists and in the tempo of the industry have all made it necessary to try to develop more systematic schemes of training for future managers.

If the training is to be of value, systematic selection is most important, and this may take place from men who have been in the industry since leaving school or from graduates. Both need, in the main, the same training, including introductory training to provide a broad knowledge of the company and its standards, and long-term development which consists of ensuring that men are placed in a succession of jobs which will give them the required experience. Small firms may find a period spent in another company of benefit in broadening the experience of trainees. In addition a potential manager can benefit greatly from outside studies of (*a*) management subjects, (*b*) advanced scientific or technical subjects, and (*c*) organisation of work, production engineering and work study.

Among the specific recommendations are that companies should, in consultation with the universities, endeavour to plan the vacation training of students in such a way as to give them practical experience, including manual labour; that facilities should be given to potential managers for release from work at least equal to that given to apprentices; and that use should be made of residential and sandwich courses.

It is recommended that the Training Committee of the B.I.S.F. should undertake a study of the whole question of selection and, at suitable intervals, appoint a special committee to review the facilities which exist for advanced technical courses in specialised subjects. A series of experimental courses for suitable men with the necessary experience should be organised on a national basis by the Federation.

# SOLID-FUEL-FIRED GAS TURBINES IN GREAT BRITAIN

## THE DESIGN OF PULVERISED-COAL BURNING SYSTEMS

*By A. Fitton*, B.SC., PH.D., A.M.I.MECH.E., M.I.CHEM.E., *and R. G. Voysey*, B.SC., A.C.G.I., WH.SC., A.M.I.MECH.E.

*In this article the authors discuss the potentialities of the solid-fuel burning gas turbine and outline the progress already made in its practical development. Research work has been carried out for the Ministry of Fuel and Power on a contract basis by a number of industrial companies, and their separate contributions are summarised in the second section of the article. The first section deals with factors in turbine and combustion-chamber design, including the various cycles which may be used and the problem of ash deposition. The principal fuel considered is pulverised coal, but the use of peat is also explored. The article concludes with a section on gas cleaning.*

### HANDLING PULVERISED COAL

Coal antedates the more convenient liquid fuels as a basis for industrial power and in most countries where it is indigenous, certainly in Britain, its cost is not much more than half that of oil fuels. Nearly two-thirds of the cost of generated electricity is for fuel, so coal must continue to be the main source of heat for power generation until nuclear energy becomes dominant, either because it is cheaper, or because it is the only way of supplying the prodigious quantitites of energy required for our industrial progress. The difficulties of handling coal compared with oil largely disappear if the coal is first crushed or ground to fine or pulverised form. The resulting product can be airborne and then behaves much like a fluid; for example, it can be decanted, displaced by gas or air and, using airlock or lock-hopper techniques, can be "pumped" to high-pressure regions. Its rate of flow can be changed by throttling devices which are susceptible to automatic control. In addition, it can be burnt in suitably designed combustion spaces and is thus a convenient fuel for a flexible prime-mover such as a turbine set. Pulverised fuel is already widely used for firing steam boilers and cement kilns, and its combustion has been a subject of research for many years; it was commonly felt that the use of this fuel for potentially low-cost gas turbines, which have the advantage of requiring little water, would have interesting economic possibilities.

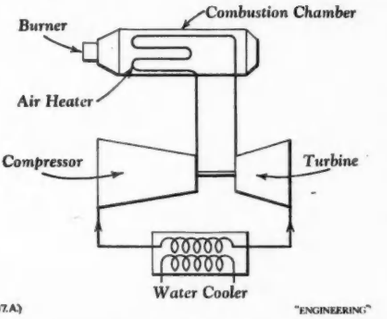


**Fig. 1 Diagrammatic layout of a closed-cycle gas turbine. Only the cycle air, which flows in an entirely closed circuit, passes through the turbine; the air heater is fired at atmospheric pressure.**

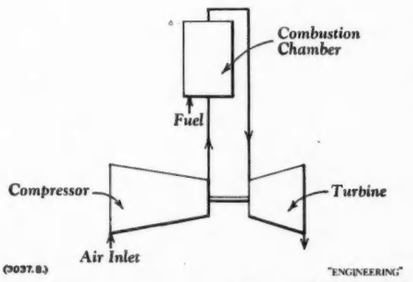


**Fig. 2 Open-cycle gas turbine. Fuel is burned at the cycle maximum pressure and the products of combustion, diluted with air, pass through the turbine at approximately 700 deg. C.**

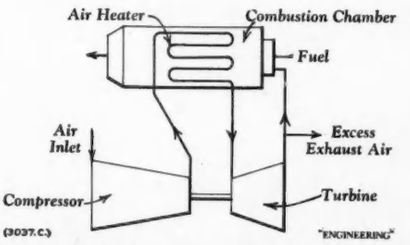


**Fig. 3 Air-heater open-cycle gas turbine. As in the closed-cycle, clean air only passes through the turbine, and combustion occurs at atmospheric pressure using some of the hot exhaust air.**

Many papers have discussed the potentialities of coal-fired gas turbines and described the research which has contributed to their development.[1, 2] In a Thomas Hawksley lecture[3] to the Institution of Mechanical Engineers, Sir Harold Roxbee Cox gave the reasons which led the Ministry of Fuel and Power to decide that their potential advantages were sufficient to justify the acceleration and application of these researches. With this in view, contracts were awarded to gas-turbine manufacturers to adapt their designs for coal burning. Much of the effort of the companies to date has been devoted to the development of the prime mover itself, and the results so far obtained apply generally to gas and liquid burning turbines and also perhaps to future nuclear-energy turbines. It has also had the effect of encouraging close collaboration of the firms with such research organisations as the Fuel Research Station of the Department of Scientific and Industrial Research and the British Coal Utilisation Research Association (under contract to D.S.I.R.) with a consequent two-way transfer of problems and information.

In general, the researches have now reached the stage where combustion and coal-handling are accepted techniques, although still capable of improvement; and, as expected, the removal of ash from the gas-stream has become the main problem. A machine in which the heat is transferred to the cycle through an air heater, has completed a thousand hours of running, and the general feasibility of the coal-burning gas turbine can be said to have been demonstrated. With cycles using the fuel internally, the need for more efficient removal of ash is still a problem, and is now receiving close attention.

### GAS-TURBINE CYCLES

The gas-turbine cycles which lend themselves most easily to the burning of solid fuels are the closed cycle, the open cycle, and the air-heater open cycle. These cycles are shown diagrammatically in Figs. 1, 2 and 3, respectively.

*Closed Cycle.*—A closed-cycle unit (Fig. 1) consists of a compressor, an air heater, a turbine and a water-cooling section. The cycle air

flows in a closed circuit and only this air passes through the turbine. The air heater, like the normal steam boiler, is fired at atmospheric pressure, and the system can be compared to the closed steam cycle in which the normal steam condenser is replaced with the water cooler. The problems are mainly economic ones associated with heat transfer and the prevention of ash deposits in the air-heater section.

*Open Cycle.*—A diagram of a simple open-cycle system is shown in Fig. 2. In this cycle the fuel is burned at the cycle maximum pressure and the products of combustion, diluted with air to bring the temperature to about 700 deg. C., are passed through the turbine. When solid fuel is used, some of the impurities in the fuels are carried forward by the gases and it becomes essential to fit a gas cleaner in the circuit to reduce fouling of the turbine blades to within tolerable limits.

*Air-Heater Open Cycle.*—A simple diagrammatic arrangement of the air-heater open-cycle gas turbine, which uses no cooling water, is shown in Fig. 3. In this system, a rather expensive air heater is used to secure the advantages of the closed cycle, so that clean air only passes through the turbine, with the combustion taking place at atmospheric pressure, using some of the hot air exhausted from the turbine.

In the three cycles briefly outlined, improvements in thermal efficiency can be obtained by fitting heat exchangers and other items, but since this is common to all three they have been omitted for simplicity.

## DRY COMBUSTION

Three main systems of combustion are employed and these may be described under the headings: "dry combustion," "slagging combustion," and "gasification." In addition, dry combustion is effected in two types of combustion chamber: the straight-through chamber and the vortex chamber.

The term "dry combustion" of solid fuel refers to conditions in which the temperature of operation is below that at which the ash would tend to fuse and form a liquid slag. In the application of solid fuel to gas turbines the dry-combustion system is generally operated with pulverised fuel, but there is no fundamental objection to using fuel in other sizes also. The problem of removing ash from the gases in a dry-combustion system is therefore that of removing particulate material. The way in which dry combustion is carried out is best explained with respect to the two forms of combustion chamber employed.

*Straight-Through Combustion Chamber.*—A typical experimental straight-through combustion chamber is shown in Fig. 4. This chamber was developed by the Fuel Research Station and is being installed at the National Gas Turbine Establishment, firstly for experiments on the influence of pressure on combustion and later for use in testing gas cleaners and ultimately for extended tests with a turbine. The primary air which carries the pulverised coal is fed to a "grid" burner which is situated centrally at the top of the cylindrical combustion chamber. Preheated secondary air also passes through the burner, and in such a way that the coal is divided into a series of thin layers with alternate layers of secondary air. The quantities of primary and secondary air are adjusted in order to achieve stable ignition followed by increasing turbulence, so giving rapid combustion.

The upper wall of the combustion chamber is refractory-lined, and is air-cooled by the diluting air. The lower section of the chamber is lined with heat-resisting steel, air-cooled on the outside and on the inside. The remaining diluting air, designed to give a final gas temperature of 700 deg. C., is introduced through holes equi-spaced at the bottom of the metal liner. The refractory walls are swept clear of ash by means of a supply of preheated tertiary air which enters the chamber around the full circumference in the annulus between the refractory wall and the refractory quarl. The refractory quarl serves a double purpose of radiating heat to the coal particles and maintaining a re-cycle flow pattern to assist stability of ignition without causing deposition of ash.

The combustion chamber shown in Fig. 4 is designed to burn about 1,300 lb. of coal per hour and to give a net output of about 2,000 h.p.

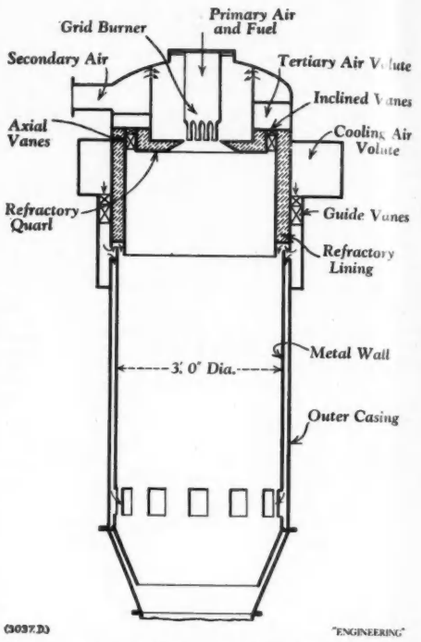


**Fig. 4 Pressurised straight-through combustion chamber. Primary air carrying pulverised coal is fed to a "grid" burner through which preheated secondary air also passes. The primary and secondary air supplies are adjusted to give stable ignition and increasing turbulence.**

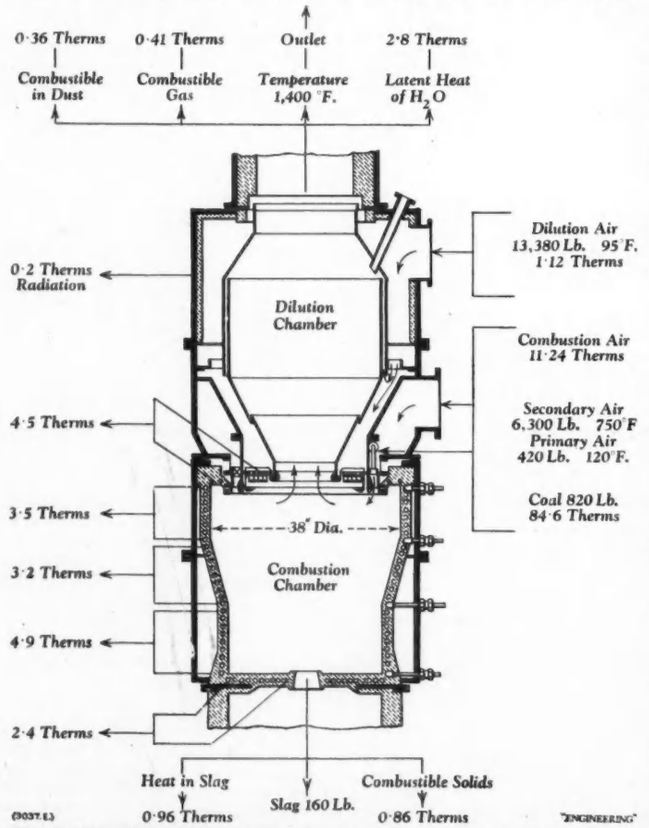


**Fig. 5 Slagging cyclone combustion chamber, showing typical performance data. Granular coal, which is centrifuged by the rotating air-stream, burns mainly on the walls of the chamber at such a temperature that the ash runs away as slag.**

## VORTEX COMBUSTION CHAMBER

A novel principle is that used in the vortex combustion chamber first considered by the Fuel Research Station in 1931, for firing Lancashire boilers with pulverised fuel.[4] One form of the combustion chamber as designed by the F.R.S. for gas-turbine use, consists of a shallow cylindrical chamber with its axis vertical. In the experimental unit the diameter is 3 ft. 3 in. and the depth 1 ft. 6 in. The "dished" top and bottom walls are made of heat-resisting steel and are air-cooled; the circumferential wall is made of refractory material. Primary air and coal enter the chamber through a number of nozzles in the top plate or in an alternative design through the refractory wall. Secondary air for combustion enters the chamber through eight or more tangential ports in the circumferential wall.

The special feature of this design is that pulverised coal tends to remain in suspension until burnt and the relative velocity between the coal particles and the air is appreciably greater than in the more conventional straight-through combustion chamber; this results in a high rate of combustion. The main difficulties experienced are associated with air flows secondary to the simple vortex pattern, which result in a tendency for ash to be deposited on the walls and for some particles of fuel to leave the chamber only partially burnt.

## SLAGGING COMBUSTION CHAMBER

Slagging combustion chambers for burning solid fuel are of two main types: firstly, the straight-through unit fired with pulverised coal and secondly, a cyclone combustion chamber fired with granular fuel of size $\frac{1}{16}$ in. to 0. Most experience has been gained on the cyclone combustion chamber which was developed in America by Babcock and Wilcox, Limited, for firing steam boilers.[5] In this country the coal-fired cyclone combustion chamber has been developed for use in gas turbines by B.C.U.R.A., under a D.S.I.R. contract, as part of the programme of the Fuel Research Board.

The latest form of the experimental combustion chamber is shown diagrammatically in Fig. 5, which also gives typical performance data. The unit operates at atmospheric pressure and burns about 700 lb. of coal per hour. In general the coal used has an ash content of from 10 to 25 per cent.

The granular coal and primary air enter the combustion chamber through four swirl nozzles, as indicated in Fig. 5, and preheated secondary air enters the chamber through swirl vanes in the annulus at the same radius as the primary-air nozzles. The coal is centrifuged by the rotating air-stream and burns mainly on the walls of the combustion chamber at such a temperature that the ash in the fuel becomes liquid and runs away as slag through the central opening in the base of the combustion chamber.

The hot products of combustion leave the

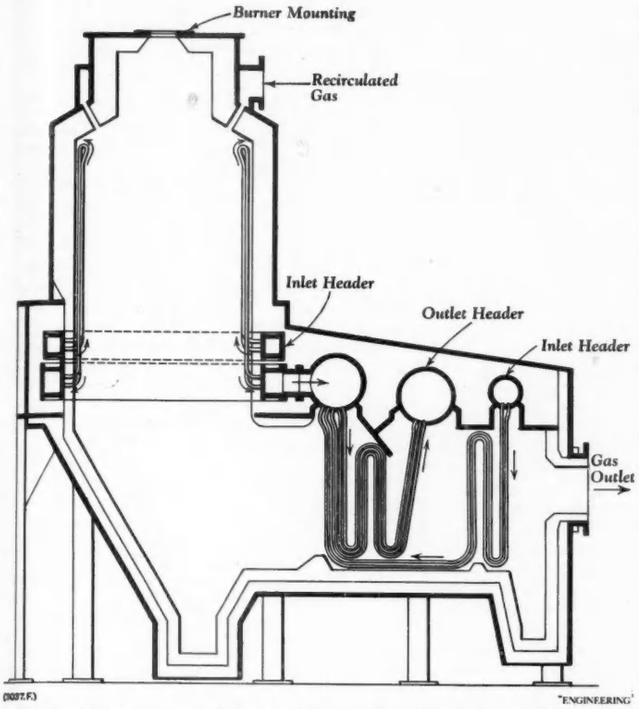


**Fig. 6 Section of peat-fired air heater. The John Brown and Company experimental gas turbine runs on a closed cycle using a tubular heat exchanger, which has first a parallel-flow radiation bank and then a cross-flow convection bank, as shown.**

cyclone through the central opening at the top of the chamber and are then diluted with pre-heated air to give a final gas outlet temperature of 700 to 750 deg. C. In the experimental unit the walls of the combustion chamber are water-cooled for measurement of the heat losses, but in a commercial unit air cooling would be used. The water-cooled tubes are initially covered with a layer of plastic refractory which is adequate for starting up the plant but the refractory is partially replaced by a layer of slag after a few hours operation; the thickness of the slag depends upon the rate of burning and the fusion properties of the ash. About 80 to 90 per cent. of the ash in the fuel is removed as slag. In such a small unit the heat losses to the cooling water amount to almost 20 per cent. of the total heat involved.

The main difficulty encountered with this system of combustion has been the tendency for slag to build up at the gas off-take throat due to the cooling effect of the diluting air. The application of this design of chamber by the English Electric Company is described later in this article.

## GASIFICATION

It has been remarked that the main difficulty with coal as a fuel follows from its ash content and the problem is further complicated by the large quantities of excess air which dilute the combustion products and thereby increase the size and complexity of the gas-cleaning equipment. An interesting possibility is first to gasify the coal with a limited quantity of air, which simplifies cleaning, and then burn this gas in the gas turbine. Because the gas producer can be near to the combustion chamber, the gas can be of low calorific value and carry as much of the total heat as temperature energy as is consistent with gas-cleaning.

A slagging cyclone was chosen as the gasifier because it should allow the use of a wide range of coals, in fine or pulverised form, with a considerable degree of ash-retention, and in addition it should favour the production of the high temperatures required for quick gasification. It was known at the start of the development that the carbon gasifying reactions take place very rapidly only at temperatures above 1,400 deg. C. Below this temperature the speed of the reactions is not much helped by extra turbulence as it is in the case of complete combustion.

## WORK BY ENGINEERING FIRMS

Various engineering companies have contributed to the development of solid-fuel burning gas turbines and their work can conveniently be outlined with reference to each of the firms concerned.

*John Brown and Company, Clydebank.*—The basis of this company's work has been their 500-h.p. experimental gas turbine which runs on a closed cycle with heat transferred to the air through a tubular heat-exchanger containing first a parallel-flow radiation bank and then a cross-flow convection bank, as shown in Fig. 6. The company made a number of chambers of various types based on the dry-burning and slagging chambers described above and they were first tested on atmospheric pressure fans. Before their coal-burning work was started for the Ministry of Fuel and Power the engine had been run for 1,000 hours on peat for the North of Scotland Hydro-Electric Board. A dry-burning chamber was finally chosen for extensive running tests on the engine with coal as fuel, and two series of runs of about 500 hours each were completed with a good quality coal and a coal slurry.

The air heater had suffered slight damage while running on peat, owing to the mildly corrosive properties of peat ash, but the results after running on coal were satisfactory. Metallurgical examination of the air-heater tubes has confirmed that all tubes which were new at the beginning of the test with coal are still in good condition, with the exception of one of the high-nickel alloy tubes which shows mild sulphur attack. Further running with an untreated small coal is continuing.

The company has just brought into operation a 1,000-kW coal-fired, closed-cycle unit which not only generates electricity and is connected to the grid, but provides hot water, heated from its exhaust for the company's factory. The furnace for the air heater is side-fired, over a pool of slag, with combustion continuing upwards through a radiant heating zone before turning into a convection bank.

## ROTATING CYCLONE CHAMBER

The company's experiments showed that while a slagging combustion chamber was attractive in its ash-retention properties, it was almost impossible to find a refractory which could stand up to molten slag for long periods. At the Ministry's request the company has manufactured a rotating cyclone chamber in which a low speed of rotation (about one revolution per second) about a vertical axis, causes the retention of a thick (over 1 ft.) layer of frozen and fused slag on the walls. Combustion takes place in the paraboloidal space, the floor of which consists of hot molten slag, and yet the heat losses from the chamber are small because of the thick layer of slag which can be retained.

In slagging chambers using metal walls it is essential to take out large quantities of heat (about 20,000 B.Th.U. per square foot per hour) to maintain a frozen layer of slag between the metal and the corrosive molten slag, and even then the slag layer rarely exceeds ½ in. in thickness. The rotating cyclone thus allows combustion to be conducted at higher temperatures with lower heat losses and at much lower outputs. It will be more useful for gasification and high-temperature chemical processes than for combustion. The attainable temperatures are dependent on the heat release and the degree of heat recuperation. A temperature of over 1,500 deg. C. was reached in the initial experiments with the combustion air preheated to 300 deg. C.

*C. A. Parsons and Company, Limited.*—This company has developed coal-burning with a 500-h.p. experimental gas turbine which has been in existence for over ten years, and which has been run for many thousands of hours on oil fuels. The company has made a number of experimental combustion chambers, one of which is shown in Fig. 7, based on the Fuel Research Station's dry-burning straight-through chamber. Chambers have also been tested with the engine, and the running time now totals several hundred hours. Since the turbine uses the open cycle the experiments have had to include gas-cleaning processes. Most of the running has been done with a multi-unit, aerodynamic cyclone cleaner made by another company. This cleaner removes about 70 per cent. of the ash; under these conditions a small fraction of one per cent. of the remainder is collected by the turbine but this is sufficient to limit running time to the order of 100 hours.

The main trouble with the turbine was loss of aerodynamic efficiency because of deposits. In earlier runs with a less efficient cleaner, erosion occurred at the root of the second row of stator blades, presumably due to dust being collected on the first row of moving blades, centrifuged to their tips and then flung at the stator blades. It is fairly certain that coarse particles were the cause; some changes were accordingly made in the cleaner. The material used for the first two rows of stator blades was not a very high-strength alloy and it has been replaced by Nimonic 80. Since then 70 hours of testing has caused no erosion.

## LOCOMOTIVE TURBINE

After the pulverised coal has been transferred

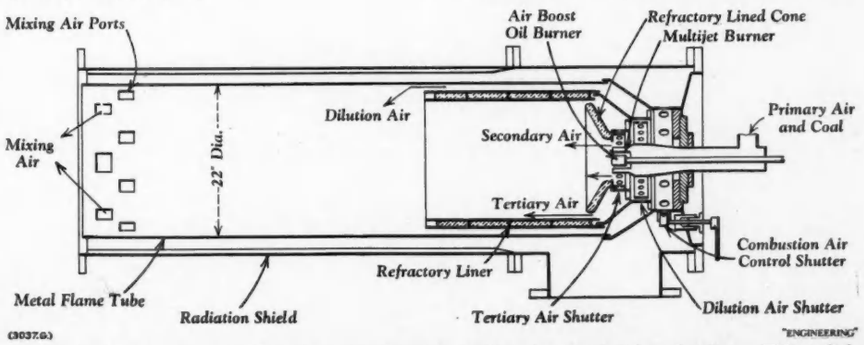


**Fig. 7 C. A. Parsons and Company experimental coal-burning combustion chamber. This unit is based on the Fuel Research Station's dry-burning straight-through chamber.**

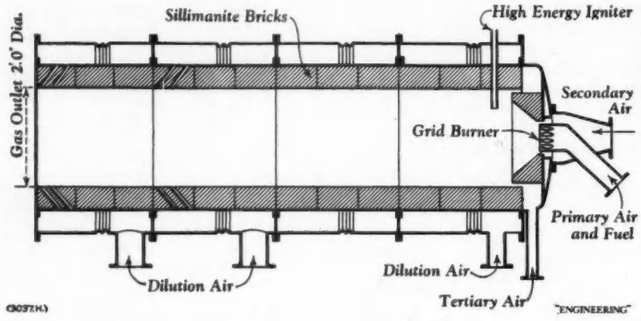


**Fig. 8 The combustion chamber employed by Ruston Hornsby, Limited, is designed for peat firing, and has a mild-steel tubular casing with a brick lining carried in a Nimonic sheath.**

into the pressure region through lock hoppers, it is kept fluidised by air for feeding, metering and burning. Work is in hand on better gas-cleaning methods and improvements in combustion. The company has also finished the design and commenced the manufacture of a 1,800-h.p. turbine for a locomotive. This uses an open cycle, but with the heat transferred through a tubular heat exchanger fired with coal, with the hot clean air from the turbine exhaust serving as combustion air.

*Ruston and Hornsby, Limited.*—The company has contracts from the Ministry of Fuel and Power for development of a peat-burning gas turbine, the set rated at 750 kW and of open-cycle type. The firm first made rig tests at atmospheric pressure on a straight-through design chamber, basically that of the Fuel Research Station, before putting it on the engine. The chamber shown in Fig. 8 has a mild-steel tubular casing and a brick lining carried in a Nimonic sheath. Casing and sheath are provided with bellows to take up differential thermal expansion and, as is common with gas-turbine chambers, the space between the two metal tubes takes most of the air flow from the compressor for cooling purposes and for final mixing with the hot gases coming from the combustion space. The grid-type burner is backed by a refractory conical quarl running at a high temperature to maintain ignition and stability.

## PEAT DRYING

This combustion system, running with the refractory walls at 900 deg. C., can burn peat with moisture contents up to 30 per cent. This content of water is so closely bound to the peat that the fibre is superficially dry. As won from the bog, peat can have moisture contents above 90 per cent., that is, ten parts of water to one of dry solids. A small fraction of this water is bound to the peat and can only be removed quickly by heating to the point of charring; a further amount of water disperses the peat in a colloidal form and the rest of the water is trapped in the jelly-like structure. If the moisture content of the peat can first be reduced to, say, 60 per cent. by mechanical methods, then there is sufficient exhaust heat available from the gas turbine at an adequate temperature for final drying.

A prominent feature of the Ministry of Fuel and Power's programme has been the development of presses and peat-mixing techniques to remove mechanically more than half the moisture in the original peat and a prototype unit has been constructed.

*English Electric Company.*—This company has so far concentrated on a slagging cyclone chamber used in conjunction with a 2,000-kW set. The system was originally described in the Hawksley Lecture previously mentioned[3], but in its present form is shown in Fig. 9. The design generally follows that of the B.C.U.R.A chamber, as described in the paragraphs on slagging combustion. Whereas in the experimental arrangement at B.C.U.R.A. it was convenient to use water-cooled walls, the combustion chamber for the English Electric Company has austenitic-steel walls liberally provided with external secondary surface to transfer heat to the cooling air passing around the flame tube.

## ASH SEPARATORS

The necessary cooling of the walls makes it difficult to run such a chamber on atmospheric air supply at the lower heat release. Consequently, very little rig testing of this chamber could be done before it was coupled to the engine. When fully developed the cyclone chamber is expected to retain over 70 per cent. and perhaps over 90 per cent. of the ash, but the hot-gas circuit is in any case provided with sixteen 10-in. diameter centrifugal ash separators, operating in parallel on the full engine mass flow.

At the time of writing the chamber has only run for about 20 hours, with turbine inlet temperatures under 625 deg. C. During this time some deposit has appeared on the turbine blades. Examination of the centrifugal cleaners suggested that for a period of the running, the cyclone combustion chamber had been passing over a large amount of ash. It should also be noted that the coal used for these runs contained 24 per cent. ash.

*Joseph Lucas, Limited and Incandescent Heat, Limited.*—The pilot-model gasifying apparatus has been described[3] and Fig. 10 shows the slagging cyclone made by Incandescent Heat, Limited, and developed at Joseph Lucas, Limited. It is rated at 200 lb. of coal per hour and has been operated at pressures up to five atmospheres. The gasifying air is varied between four and five times the coal rate by weight, and water can be added (up to half the coal rate) to control the top temperature. While water increases the hydrogen content of the gas it also increases the carbon dioxide and does not much improve the overall calorific value; indeed, if it is used to reduce the reaction temperatures below the 1,400 deg. C. quoted as necessary for rapid gasification, its effects are detrimental. A clean gas of about 100 British thermal units per cubic foot is obtained, with less than 5 per cent. of the original carbon passing over unburnt.

## GASIFICATION RATE AND TEMPERATURE

The long series of short runs made to date suggest that further benefits in gasification rate and reduction of unreacted carbon could be obtained with higher temperatures, but a limit is set by the allowable temperature on the refractory wall in the presence of slagging ash. Better refractories, a larger output chamber (so that wall cooling is less of a thermal drain on the gasification) and methods of construction which would reduce the heat losses without damaging the walls are all steps which are receiving attention. Laboratory tests suggest that certain grades of silicon-carbide refractory stand up best to molten slag. A larger cyclone gasifier for the 2,000-kW turbine is being designed and developed at Power Gas and it is possible that the spinning cyclone mentioned under John Brown and Company's work may be helpful.

The price paid for abandoning gasification in a solid bed of fuel (which is restrictive on coal type and size, especially with large outputs) is that heat regeneration has to be performed outside the producer. In the experimental set-up the required air-inlet temperature is obtained partly with heat exchangers and partly by burning paraffin in the air stream. The vitiation caused by the latter can be corrected by adding oxygen.

Runs have been made with steam addition, which is not so chilling as water, but this is not so valuable for the gas-turbine application as it would be if the gas were required for other purposes, say, for synthesis processes.

## GAS CLEANING

*Extent of Problem.*—The problem of ash is a mixed one of deposition and, to a certain extent, erosion and corrosion, embracing both physical and chemical factors. Compared with residual oil, solid fuel has in general much more ash but does not contain such extremely corrosive elements as vanadium, and at temperatures under 850 deg. C. corrosion due to ash has not been very noticeable. (A possible exception to this is peat ash, small in quantity but with a larger proportion of sodium compounds). On the other hand the chemical bonding of the ash particles has resulted in the build-up of large deposits which have caused trouble both in the combustion chamber and in the turbine.

In cycles using air heaters the effect is no more serious than in a steam boiler. The tube-metal temperatures may be slightly higher but by using radiation transfer of heat, the ash need not be brought near the tubes until the temperature of the carrying gases is below 1,000 deg. C. A thousand hours' running experience has shown that deposits can be removed by soot-blowing and that corrosion by molten ash is almost negligible.

The technical difficulties are naturally much more severe in the case of the open cycle where the comparatively small bulk of the turbine blading is directly exposed to ash in the gas stream Fortunately, the turbine is a poor collector of ash. Thus in a typical run of over 100 hours on an open-cycle turbine, 4 tons of ash were released in the combustion chamber, three of which were almost immediately collected by cyclone separators. The remaining ton was dispersed throughout the system, a large proportion in the heat exchanger, but less than 1 lb. in the turbine. Nevertheless, a very small amount of ash adhering to the blades can upset their aerodynamic form and reduce their efficiency, quite apart from any erosion or corrosion damage which may ensue. This problem was apparent before the start of the development

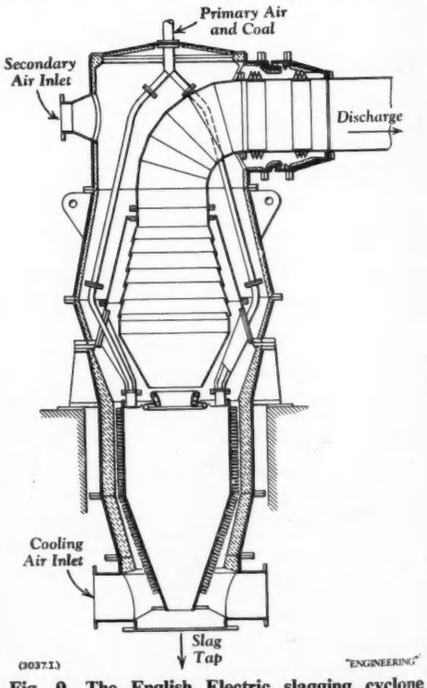


**Fig. 9 The English Electric slagging cyclone chamber is based on a B.C.U.R.A. design but has austenitic-steel walls. These are liberally provided with external secondary surface, through which heat is transferred to cooling air passing round the flame tube.**

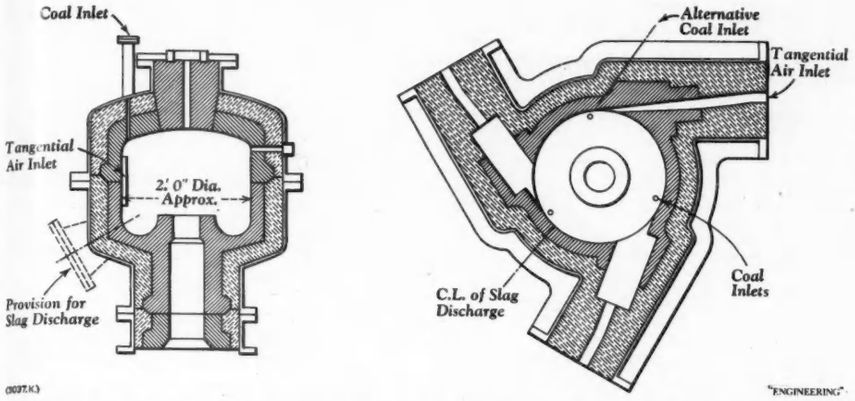


**Fig. 10 Slagging cyclone gas producer made by Incandescent Heat, Limited, and developed by Joseph Lucas, Limited. A clean gas of about 100 B.Th.U's. per cubic foot is obtained, with less than 5 per cent. of the original carbon passing over unburnt.**

and had been encountered by one of the authors on residual-oil-burning gas turbines. If, in the latter case, the ashes are of the bonding type, they usually contain sufficient water-soluble constituents to allow cleaning by periodical washing of the turbine while running.

### CLEANING AND FILTRATION

While it was important not to pre-judge the issue, there appeared sufficient grounds for confidence that if mechanical and aerodynamic gas cleaners could be improved somewhat beyond their present standards (there are grounds in theory at least for this), the problem of ash from solid fuels might be reduced to one of minor deposition, which periodic cleaning with water could cure. There was a general feeling in this country and abroad in the early stages of the work that the difficulty was mainly a mechanical one and that the removal of particles larger than 10 microns would solve most of the problems.

*Present Methods.*—Gas cleaning is an important and specialist field and cannot be treated here in much detail, but in the context of coal-burning gas turbines most workers have felt that the first and easiest approach would be to try out aerodynamic cleaners of which the so-called vortex or cyclone types are the best known. Such cleaners have no moving parts and therefore no severe stressing problems at the temperatures encountered. They can be constructed relatively cheaply from sheet metal, even using expensive alloys, and are employed extensively in chemical industries and elsewhere.

A number of proprietary cleaners have been tested together with other cleaners designed on the advice of the research workers in this field. It has been found that most of the existing types of cleaner are inadequate for application to gas turbines, not because they cannot be designed to attain the required degree of cleaning but because complications, perhaps not envisaged in the design, for example secondary flows and unexpected aerodynamic behaviour, cause a substantial proportion of particles to pass to the turbine. As single units or banks of smaller units in parallel they can be designed easily to take out 70 per cent. of the ash, and with some difficulty, over 90 per cent. of the ash, so they are very suitable for rough or preliminary cleaning. All sorts of minor complications arise with their use, for example, under some conditions ash may become bonded inside them; ash may be transferred from one unit to another when they are operated in parallel; and they also have a tendency to retain the larger, drier fraction of the ash and pass on the small, perhaps sublimable, fraction, which can cause strong bonding. However, none of these difficulties is very serious for rough cleaning only. Existing types of cleaner are attractive as a subject for research and their development to rather higher efficiencies is in hand.

*Future Trends.*—There is no doubt that other methods must be found to remove almost all the remaining fraction of ash passed over by preliminary cleaners as mentioned above. Some thought and experiment has been devoted to electrostatic cleaning. The capital cost is not unduly high, and experiments have shown that the electrical consumption required (probably about 2 per cent. of the set's output) although not low is tolerable. Electrical precipitation is therefore a residual possibility if cheaper methods cannot be found. At the present moment research is being conducted on a number of approaches namely, filtration through porous metal and ceramic filters, and centrifuging with rotary devices, but it is too early to make much comment on the long-term prospects of these devices.

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[1] Hurley, T. F. "Combustion Chamber for Coal-Fired Gas Turbines," Inst. of Petroleum (1951).
[2] Karthauser, F. B. "Pulverised fuel Firing for Stationary Gas Turbines," Harrogate Conference on Pulverised Fuel, June, 1947, report published by the Institute of Fuel.
[3] Roxbee Cox, H. "Some Fuel and Power Projects," 38th Thomas Hawksley Lecture, *Proc. I.Mech.E.*, vol. 164(4), page 407 (1951).
[4] Hurley, T. F. "Factors Affecting the Design of a Small Combustion Chamber for Pulverised Fuel," Inst. of Fuel (April, 1931).
[5] Grunert, A. E., Skog, L., and Wilcoxon, L. S. "Horizontal Cyclone Combustion Chamber," *Trans. A.S.M.E.*, vol. 69, page 613 (1947).

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## TELEPHONE COMMUNICATIONS IN AUSTRIA

The main route of a national telephone system, consisting of coaxial cable with associated carrier systems, was recently inaugurated by the Austrian Postal Administration. This network connects the more important traffic junctions in the country and extends from Feldkirch in the west through Innsbruck, Worgl, Bischofshofen, Salzburg, Ried, Linz, Amstetten and St. Polten to Vienna in the east. A second route running from Bruck through Graz, Hartberg and Wiener Neustadt to Vienna is also being installed and will be connected with an existing cable between Salzburg and Bruck.

Over 3,000 km. of 9·5-mm. coaxial tube has been manufactured by Standard Telephones and Cables, Limited, Aldwych, London, W.C.2, for the network and has been made up into two-tube and four-tube armoured cables with a total length of 1,000 km. The carrier systems employed have operating frequency bandwidths of 2·6 and 4 megacycles respectively. Up to 600 or 960 telephone channels can be accommodated within these bandwidths, but the maximum potential capacity of the four-tube cables installed in many of the sections is either 1,200 to 1,920 telephone circuits.

The signals are amplified at the terminal stations, and at main and dependent repeater stations which are spaced at average intervals of about 9·6 km. When completed, the network will comprise six terminal stations, ten main power-feeding repeaters (many of which will serve smaller towns) and 113 dependent repeaters. Power supplies for the unattended dependent repeaters will be obtained over the coaxial cable from the terminal and main repeaters.

In planning the network, consideration was given not only to fully automatic operation within Austria, but also to integration with the semi-automatic international system which is taking shape in Europe.

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## ROLLING MILL FOR AUSTRIAN STEELWORKS

### *Beam and Section Production at Donawitz*

A two-high reversing roughing rolling mill, now assisting in producing standard structural-steel shapes in an Austrian steelworks, has been built by the Lewis Machinery Division of the Blaw-Knox Company, Pittsburgh, U.S.A. It forms part of a complete structural mill erected for the Oesterreichische-Alpine-Montangesellschaft, A.G., Donawitz.

The rolls in the two-high mill have a pitch diameter of 36 in. and a total body length of 82 in. Owing to the large-diameter collars required for the beam-sections rolled, the housing windows are 54 in. wide, the equivalent of those usually found in 44- or 46-in. mills; the housing posts have a cross-sectional area of 425 square inches. The mill screw-down gear is operated through worm-gear drives rotated by two 100-h.p. motors. The screws are 13 in. in diameter and have a pitch of approximately 2 in.; they operate at a speed of 160 in. per minute.

Universal spindles for the upper and lower rolls, 18 in. in diameter and 15 ft. long, connect the mill with a two-high pinion housing containing 36 in. by 48 in. double-helical pinions, forged from alloy steel and subsequently flame hardened. The mill is driven by a 6,300-h.p. 69-140 r.p.m. direct-current motor capable of reversing the mill from a speed of 69 r.p.m. in the forward direction to 69 r.p.m. in the opposite direction in two seconds. Front and rear roller tables are provided, each equipped with 15 rollers. The rollers are 16 in. in diameter and 82 in. long and are spaced at 21 in. intervals. Each table is driven by two 75-h.p. motors running at a speed of 723 ft. per minute. Both the front and the rear tables are provided with a pair of rack-type side-guard manipulators 28½ in. high for handling the heavy beam blanks coming to the mill.

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## INDUSTRIAL ULTRASONIC GENERATOR

The low frequency ultrasonic generator now being produced by Mullard Limited, Shaftesbury-avenue, London, W.C.2, is a general-purpose equipment with an output of 2 kW and a frequency range of 10 to 30 kilocycles.

The generator consists essentially of a variable frequency oscillator of the Wien bridge type. This feeds an amplifier followed by a driver and push-pull output stage, which is transformer-coupled to the load. The output current and the anode currents of the output valves are monitored. The output power is controlled by a variable attenuator in the amplifier stage.

In the power-pack high tension current for the output stage is derived from a bridge rectifier using rare gas valves with a short warming-up time. Vacuum rectifiers are employed for the other high tension supplies; and a variable low voltage direct-current polarising supply is derived from a bridge circuit incorporating metal rectifiers.

# BENDING OF A STRAIGHT BEAM UNDER TRANSVERSE LOADING

## WORKED EXAMPLES DEMONSTRATING THE USE OF IMPULSE AND STEP FUNCTIONS

*By A. W. Gillies**

*Concluded from page* 213

*Last week, on page* 211, *the author discussed the general problem of the use of impulse and delta functions for developing the general solution of the bending of an initially straight beam. Their use in specific examples is demonstrated below.*

### ORIGIN TAKEN AT LEFT-HAND END OF BEAM

(i) *Single Concentrated Load on a Beam with Built-in Ends*, as in Fig. 3.

Here $y_0 = \theta_0 = 0$ and the rate of loading equation is

$$w = \mathrm{F}\,\delta(a).$$

Successive integrations then give

$$-\mathrm{S} = -\mathrm{S}_0 + \mathrm{F}\{x-a\}^0$$

$$\mathrm{M} = \mathrm{M}_0 - \mathrm{S}_0 x + \mathrm{F}\{x-a\}$$

$$\mathrm{E\,I}\,\theta = \mathrm{M}_0 x - \mathrm{S}_0\frac{x^2}{2} + \mathrm{F}\frac{\{x-a\}^2}{2}$$

and

$$\mathrm{E\,I}\,y = \mathrm{M}_0\frac{x^2}{2} - \mathrm{S}_0\frac{x^3}{6} + \mathrm{F}\frac{\{x-a\}^3}{6}.$$

The conditions determining $\mathrm{S}_0$ and $\mathrm{M}_0$ are $\theta = y = 0$ at $x = l$; thus

$$0 = \mathrm{M}_0 l - \mathrm{S}_0\frac{l^2}{2} + \mathrm{F}\frac{(l-a)^2}{2}$$

$$0 = \mathrm{M}_0\frac{l^2}{2} - \mathrm{S}_0\frac{l^3}{6} + \mathrm{F}\frac{(l-a)^3}{6}$$

and the solution is

$$\mathrm{S}_0 = \frac{\mathrm{F}\,b^2(l+2a)}{l^3},\quad \mathrm{M}_0 = \frac{\mathrm{F}\,b^2 a}{l^2}.$$

The external force and moment at $x = 0$ are the negatives of these, i.e.,

$$-\frac{\mathrm{F}\,b^2(l+2a)}{l^3} \quad\text{and}\quad -\frac{\mathrm{F}\,b^2 a}{l^2}.$$

Interchanging $a$ and $b$ gives the external force and moment at $x = l$ as

$$-\frac{\mathrm{F}\,a^2(l+2b)}{l^3} \quad\text{and}\quad +\frac{\mathrm{F}\,a^2 b}{l^2}$$

respectively.

The static equilibrium of the beam gives a check on the arithmetic. Thus the sum of the reactions is

$$-\frac{\mathrm{F}}{l^3}[b^2(l+2a) + a^2(l+2b)]$$

$$= -\frac{\mathrm{F}}{l^3}[l(a^2+b^2) + 2ab(a+b)]$$

$$= -\frac{\mathrm{F}}{l^3}[l(a^2+2ab+b^2)]$$

$$= -\mathrm{F}.$$

Alternatively $\mathrm{S}_0$ and $\mathrm{M}_0$ may be determined initially from static considerations.

* Department of Mathematics, Northampton Polytechnic, St. John-street, London, E.C.1.

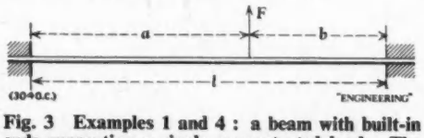


**Fig. 3 Examples 1 and 4 : a beam with built-in ends supporting a single concentrated load. The conditions for determining the constants of integration are zero deflection and slope at the supports.**

A positive (i.e. upward) load has been assumed. If the load is gravitational the sign of F must be reversed throughout.

(ii) *Simply-supported Beam Bent by a Couple at a Point on its Length*, as shown in Fig. 4.

Here $y_0 = \mathrm{M}_0 = 0$ at $x = 0$ and the rate of loading is

$$w = -\mathrm{G}\,\delta'(a).$$

Successive integration gives

$$-\mathrm{S} = -\mathrm{S}_0 - \mathrm{G}\,\delta(a)$$

$$\mathrm{M} = -\mathrm{S}_0 x - \mathrm{G}\{x-a\}^0$$

$$\mathrm{E\,I}\,\theta = \mathrm{E\,I}\,\theta_0 - \mathrm{S}_0\frac{x^2}{2} - \mathrm{G}\{x-a\}$$

and

$$\mathrm{E\,I}\,y = \mathrm{E\,I}\,\theta_0 x - \mathrm{S}_0\frac{x^3}{6} - \mathrm{G}\frac{\{x-a\}^2}{2}.$$

At $x = l$, $y = \mathrm{M} = 0$ gives

$$0 = -\mathrm{S}_0 l - \mathrm{G}$$

$$0 = \mathrm{E\,I}\,\theta_0 l - \mathrm{S}_0\frac{l^3}{6} - \mathrm{G}\frac{b^2}{2}$$

from which

$$\mathrm{S}_0 = -\frac{\mathrm{G}}{l} \quad\text{and}\quad \mathrm{E\,I}\,\theta_0 = \frac{\mathrm{G}(3b^2 - l^2)}{3l}.$$

(iii) *Simply-Supported Beam with Uniform Gravitational Loading Over the Middle Third* (Fig. 5).

$\mathrm{M}_0 = y_0 = 0$, and the rate of loading is

$$w = -\mathrm{W}\{x-l\}^0 + \mathrm{W}\{x-2l\}^0$$

$$-\mathrm{S} = -\mathrm{S}_0 - \mathrm{W}\{x-l\} + \mathrm{W}\{x-2l\}$$

$$\mathrm{M} = -\mathrm{S}_0 x - \mathrm{W}\frac{\{x-l\}^2}{2} + \mathrm{W}\frac{\{x-2l\}^2}{2}$$

$$\mathrm{E\,I}\,\theta = \mathrm{E\,I}\,\theta_0 - \mathrm{S}_0\frac{x^2}{2} - \mathrm{W}\frac{\{x-l\}^3}{6} + \mathrm{W}\frac{\{x-2l\}^3}{6}$$

and

$$\mathrm{E\,I}\,y = \mathrm{E\,I}\,\theta_0 x - \mathrm{S}_0\frac{x^3}{6} - \mathrm{W}\frac{\{x-l\}^4}{24} + \mathrm{W}\frac{\{x-2l\}^4}{24}.$$

$\mathrm{S}_0$ and $\mathrm{E\,I}\,\theta_0$ are determined by $\mathrm{M} = y = 0$ at $x = 3l$.

$$0 = -\mathrm{S}_0\,3l - \mathrm{W}\,2l^2 + \mathrm{W}\frac{l^2}{2}$$

$$0 = \mathrm{E\,I}\,\theta_0\,3l - \mathrm{S}_0\frac{9l^3}{2} - \frac{2\,\mathrm{W}\,l^4}{3} + \frac{\mathrm{W}\,l^4}{24}$$

from which $\mathrm{S}_0 = -\dfrac{\mathrm{W}\,l}{2}$, as is otherwise obvious, and $\mathrm{E\,I}\,\theta_0 = -\dfrac{13\,\mathrm{W}\,l^3}{24}$. A check is provided by calculating $\theta$ at $x = 3l$, which gives $\mathrm{E\,I}\,\theta_{3l} = +\dfrac{13\,\mathrm{W}\,l^3}{24}$, which is clearly consistent with the symmetry.

If it is preferred, the bending-moment equation may be obtained directly by taking moments about the point $x$ for the portion of the beam between 0 and $x$. This gives

$$\mathrm{M} - \mathrm{P}x + \int_l^{2l} \mathrm{W}\,d\xi\{x-\xi\} = 0$$

where $\mathrm{P} = -\mathrm{S}_0$ is the reaction at the support.

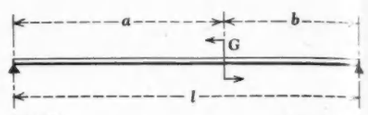


**Fig. 4. Example 2 : a simply-supported beam bent by a couple along its length. Here the characteristic conditions are those of zero deflection and zero moment at the supports.**

Thus

$$\mathrm{M} = \mathrm{P}x - \int_l^{2l} \mathrm{W}\{x-\xi\}\,d\xi$$

$$= \mathrm{P}x + \left[\frac{\mathrm{W}\{x-\xi\}^2}{2}\right]_l^{2l}$$

$$= \mathrm{P}x - \mathrm{W}\frac{\{x-l\}^2}{2} + \mathrm{W}\frac{\{x-2l\}^2}{2}$$

which is the same equation as above. This is, however, no quicker than deriving M from $w$ as in the previous solution of this problem.

### ORIGIN NOT AT LEFT-HAND END OF BEAM

It has been shown that the simplicity of the Macaulay method derives from the use of indefinite integrals which vanish at $x = 0$, so that the constants of integration at each stage are simply the values of the successive beam functions at $x = 0$. If the origin is not taken at the left-hand end of the beam, this condition is satisfied by the use of the alternative form of the Macaulay power function in connection with loads or moments on the negative side of the origin. This is illustrated in the following examples, the first two repeating previous examples with a different choice of origin.

(iv) *Single Concentrated Load on a Beam with Built-in Ends* (Fig. 3).

Take the origin at the right-hand end of the beam, the beam extending from $x = 0$ to $x = -l$. (Note that the positive sense has not been altered.) The conditions at $x = 0$ are $\theta_0 = y_0 = 0$ and for the rate of loading we have

$$w = \mathrm{F}\,\delta(-b).$$

Successive integration gives

$$-\mathrm{S} = -\mathrm{S}_0 - \mathrm{F}\{-b-x\}^0$$

$$\mathrm{M} = \mathrm{M}_0 - \mathrm{S}_0 x + \mathrm{F}\{-b-x\}$$

$$\mathrm{E\,I}\,\theta = \mathrm{M}_0 x - \mathrm{S}_0\frac{x^2}{2} - \mathrm{F}\frac{\{-b-x\}^2}{2}$$

and

$$\mathrm{E\,I}\,y = \mathrm{M}_0\frac{x^2}{2} - \mathrm{S}_0\frac{x^3}{6} + \mathrm{F}\frac{\{-b-x\}^3}{6}.$$

At $x = -l$, we have $\theta = y = 0$, giving

$$0 = -\mathrm{M}_0 l - \mathrm{S}_0\frac{l^2}{2} - \mathrm{F}\frac{a^2}{2}$$

$$0 = \mathrm{M}_0\frac{l^2}{2} + \mathrm{S}_0\frac{l^3}{6} + \mathrm{F}\frac{a^3}{6}$$

the solution of which is

$$\mathrm{S}_0 = -\frac{\mathrm{F}\,a^2(l+2b)}{l^3},\quad \mathrm{M} = \frac{\mathrm{F}\,a^2 b}{l^2}$$

in agreement with the previous solution.

(v) *Simply Supported Beam with Uniform Gravitational Loading Over the Middle Third* (Fig. 5).

Take the origin this time at the centre of the

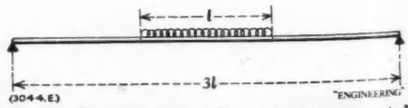


**Fig. 5 Examples 3 and 5 : a simply-supported beam with a uniform load over the middle third. As in example 2, the conditions are of zero deflection and moment over the supports.**

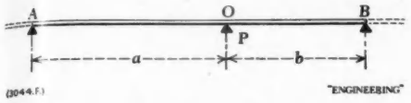


**Fig. 6 Example 6: the theorem of three moments. The method described gives a convenient procedure for deducing the theorem of three moments for a beam with a uniformly distributed load.**

beam. We shall then have, from the symmetry, $S_0 = \theta_0 = 0$. Thus we have

$$w = -W + W\left\{x - \frac{l}{2}\right\}^0 + W\left\{-\frac{l}{2} - x\right\}^0$$

$$-S = -Wx + W\left\{x - \frac{l}{2}\right\} - W\left\{-\frac{l}{2} - x\right\}$$

$$M = M_0 - W\frac{x^2}{2} + W\frac{\left\{x - \frac{l}{2}\right\}^2}{2} + W\frac{\left\{-\frac{l}{2} - x\right\}^2}{2}$$

$$EI\theta = EI\theta_0 + M_0 x - W\frac{x^3}{6} + W\frac{\left\{x - \frac{l}{2}\right\}^3}{6} - W\frac{\left\{-\frac{l}{2} - x\right\}^3}{6}$$

and

$$EIy = EIy_0 + EI\theta_0 x + M_0\frac{x^2}{2} - W\frac{x^4}{24} + W\frac{\left\{x - \frac{l}{2}\right\}^4}{24} + W\frac{\left\{-\frac{l}{2} - x\right\}^4}{24}.$$

The constants $M_0$ and $y_0$ are determined by $M = y = 0$ at $x = \frac{3l}{2}$.

Thus we have

$$0 = M_0 - W\frac{9l^2}{8} + W\frac{l^2}{2}$$

$$0 = EIy_0 + EI\theta_0\frac{3l}{2} + M_0\frac{9l^2}{8} - W\frac{81l^4}{384} + W\frac{l^4}{24}$$

the solution of which is $M_0 = \frac{5Wl^2}{8}$ and $EIy_0 = -\frac{205Wl^4}{384}$. These are the values of M and EI$y$ given by putting $x = \frac{3l}{2}$ in the previous solution.

In these two examples, the use of the right-hand or central origin is unnecessary and they serve merely to show that there is no difficulty in its use. In the second case, because of the symmetry, only the right half of the beam need be considered, the end conditions at $x = -\frac{3l}{2}$ not being used.

Perhaps a better example is given by the classical theorem of three moments which is considered next.

(vi) *Theorem of Three Moments* (Fig. 6).

Here we wish to relate the bending moments at three successive supports A, O, B on a continuous beam with uniform loading $-W$ (gravitation loading is assumed though it makes no essential difference).

Take origin at O, and let deflections be measured relative to O, i.e. $y_0 = 0$. Let P be the reaction at the support O. Then we have for $-a < x < b$

$$w = -W + P\delta(0)$$

$$-S = -S_0 - Wx + P\{x\}^0$$

$$M = M_0 - S_0 x - W\frac{x^2}{2} + P\{x\}$$

$$EI\theta = EI\theta_0 + M_0 x - S_0\frac{x^2}{2} - W\frac{x^3}{6} + P\frac{\{x\}^2}{2}$$

and

$$EIy = EI\theta_0 x + M_0\frac{x^2}{2} - S_0\frac{x^3}{6} - W\frac{x^4}{24} + P\frac{\{x\}^3}{6}.$$

At $x = b$, we have

$$M_B = M_0 - S_0 b - W\frac{b^2}{2} + Pb$$

and

$$EIy_B = EI\theta_0 b + M_0\frac{b^2}{2} - S_0\frac{b^3}{6} - W\frac{b^4}{24} + P\frac{b^3}{6}.$$

At $x = -a$, similarly,

$$M_A = M_0 + S_0 a - W\frac{a^2}{2}$$

and

$$EIy_A = -EI\theta_0 a + M_0\frac{a^2}{2} + S_0\frac{a^2}{6} - W\frac{a^4}{24}.$$

From the first pair $S_0$ and P are eliminated together, and

$$bM_B - \frac{6EIy_B}{b} = -6EI\theta_0 - 2bM_0 - W\frac{b^3}{4}.$$

Eliminating $S_0$ from the last pair in the same way

$$aM_A - \frac{6EIy_A}{a} = 6EI\theta_0 - 2aM_0 - W\frac{a^3}{4}$$

and adding the last two equations eliminates $\theta_0$. Final re-arranging gives

$$aM_A + 2(a+b)M_0 + bM_B = 6EI\left(\frac{y_A}{a} + \frac{y_B}{b}\right) - \frac{W}{4}(a^3 + b^3)$$

which is the result required.

It should be noted in this example that we have a concentrated load at the origin, namely the reaction at the support. The term $P\delta(0)$ could have been integrated in either of the forms $P\{x\}^0$ or $-P\{-x\}^0$. The first, which was actually used, treats P as though it were slightly to the right of the origin, and hence $S_0$ is the shearing force just to the left of the support. Had the alternative form been used, the load would have been regarded as slightly to the left of the origin, and $S_0$ would then have represented the shearing force on the right of the support. The working would then have differed only by the P terms occurring in the other pair of equations, the result being obtained exactly as before.

## CONCLUSION

To recapitulate the procedure, the equation for the rate of loading is written down following the usual Cartesian co-ordinate convention, usually with the origin at the left-hand end of the beam. Any concentrated loads are included as the magnitude of the load, with correct sign multiplied by the delta function with singularity at the point of application of the load. Concentrated moments are likewise included as the magnitude, with correct sign, times minus the delta dashed function with singularity at the point of application. Thus all the information regarding the loading is included in this equation.

Four integrations give in succession $-S$, M, EI$\theta$ and EI$y$, the constants of integration being the values of these quantities at $x = 0$, the integrals used being those which vanish at $x = 0$. Two of these constants will in most cases vanish according to the conditions of support at $x = 0$. The other two are determined by the conditions of support at the far end of the beam. The requirements of static equilibrium of the beam as a whole give a check on the working.

The special functions used with their differential coefficients, and integrals vanishing at $x = 0$ are summarised in the accompanying table.

It will be seen that once the first equation has been written down the complete solution follows from the elementary rules for integration. The tricky questions of sign which so frequently baffle students when dealing with moments and internal forces are avoided and there is no need to try and anticipate the solution by deciding in advance whether the beam is sagging or hogging. Such questions will be decided with certainty by the solution itself.

Finally it may be remarked that delta functions and step functions have been widely used in connection with operational calculus and Laplace transform methods.[2] Few engineers on the mechanical side however are familiar with such methods, whereas in the procedure discussed here there is nothing that need be beyond the capacity of a National Certificate student.

*Table of Differential Coefficients and Integrals*

| Function | Differential Coefficient | Indefinite Integral, Vanishing at $x = 0$ | Limitations |
|---|---|---|---|
| Power functions | | | |
| $\{x-a\}^n$ | $n\{x-a\}^{n-1}$ | $\frac{\{x-a\}^{n+1}}{n+1}$ | $n > 0, a > 0$ |
| $\{a-x\}^n$ | $-n\{a-x\}^{n-1}$ | $-\frac{\{a-x\}^{n+1}}{n+1}$ | $n > 0, a < 0$ |
| Step function | | | |
| $\{x-a\}^0$ | $\delta(a)$ | $\{x-a\}$ | $a > 0$ |
| $\{a-x\}^0$ | $-\delta(a)$ | $-\{a-x\}$ | $a < 0$ |
| Concentrated-load delta function | | | |
| $\delta(a)$ | $\delta'(a)$ | $\{x-a\}^0$ | $a > 0$ |
| | | $-\{a-x\}^0$ | $a < 0$ |
| Concentrated-moment function | | | |
| $\delta'(a)$ | — | $\delta(a)$ | — |

[2] *Transients in Linear Systems, Vol. I*, by Gardner and Barnes. John Wiley & Sons, New York (1942).

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## RESEARCH ON CORROSION IN THE UNITED STATES

Formed with the aid of the American Institute of Mining and Metallurgical Engineers the Intersociety Corrosion Committee and the Electrochemical Society, the main object of the Corrosion Research Council of the Engineering Foundation, 29 West 39th-street, New York, U.S.A., is to intensify the research effort on corrosion.

As a first step it is planned to request industry to subscribe a sum of 200,000 dols. to enable a start to be made.

Dr. H. H. Uhlig, chief of the corrosion laboratory of the Massachusetts Institute of Technology is to head the organising committee of the Corrosion Research Council. Other members include Mr. A. V. Astin, director of the U.S. National Bureau of Standards; Mr. F. L. La Que, vice president and head of the development and research division of the International Nickel Company, Incorporated, New York; Mr. W. J. Sweeney, vice-president, Esso Research and Engineering Company; Mr. R. M. Burns, former director of the chemical and metallurgical research division, Bell Telephone Laboratories; Dr. R. B. Mears, manager, applied research laboratory, United States Steel Corporation; and Mr. R. M. Wick of the Bethlehem Steel Company, who is chairman of the Intersociety Corrosion Committee.

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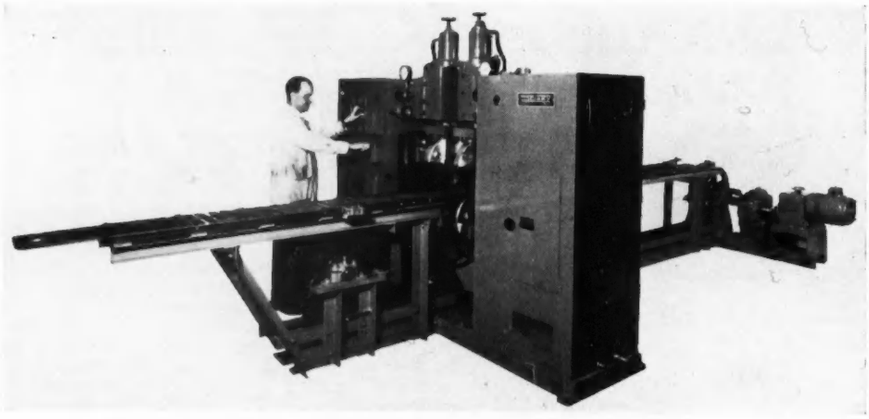
## STRESS ANALYSIS

### Sheffield Conference Next Month

The ninth annual conference of the Stress Analysis Group of the Institute of Physics will be held at the Stephenson Hall, The University, Sheffield, 10, from Wednesday, September 28, to Friday, September 30, 1955. The meeting will take the form of a general conference on recent developments in the application of stress analysis. Papers to be read will include a number by authors from overseas and arrangements have been made for visits to be paid to laboratories and works in the Sheffield area. Further information may be obtained from the secretary of the Institute, 47 Belgrave-square, London, S.W.1.



150-kVA conveyor-drive seam welding machine.

## SEAM WELDING OF LONG FLAT COMPONENTS

The accompanying illustration shows a conveyor-drive seam welding machine, which has been produced by Sciaky Electric Welding Machines, Limited, Farnham-road, Slough, for making two parallel seams simultaneously on long flat components, such as radiator sections, reinforced steel floor sections, roofs, walls and doors.

As will be seen, the machine consists of two welding units, which are mounted facing each other on a common base plate with a central conveyor and guide assembly between them. The right-hand unit incorporates a transformer and air pressure system, while in addition the left hand section contains mechanism for initiating and controlling the speed of the conveyor, as well as devices for adjusting the current and the air pressure on both units. The conveyor can be started by pressing a push-button, the component then being placed on the loading end of the conveyor and traversed between the electrode wheels. Both the top welding wheels are then brought down on to the welding face and the welding current is initiated, the whole action being automatic. On reaching the end of the seam the component automatically switches off the current and lifts the electrode wheels clear of the welding face. Finally, the component is automatically ejected at the discharge end.

The transformer with which the machine is equipped is rated at 150 kVA on a 90-per cent. duty cycle. The welding pressure is adjustable up to a maximum of 1,000 lb. and the conveyor speed can be varied from 3 to 9 ft. per minute. The welding current is controlled by a synchronous ignitron with phase-shift heat regulation. Water cooling is provded throughout. The baseplate can be extended and the hand unit made adjustable for position, so as to accommodate various widths of components. The machine can also be arranged to produce more than two seams simultaneously; and to carry out roller spot welding where a pressure-tight seam is not required.

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## CHEMICAL RESEARCH LABORATORY

### Open Days

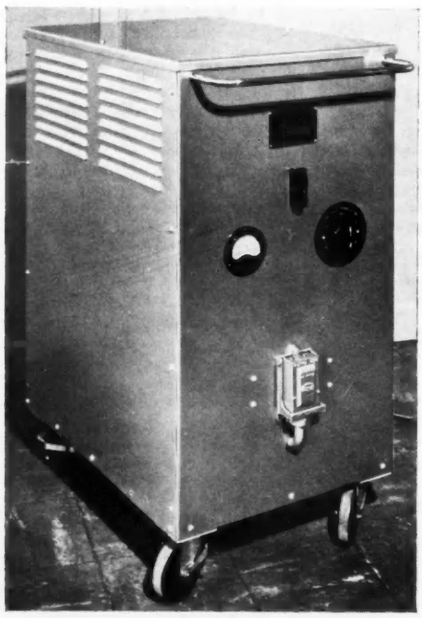
A series of open days has been arranged at the Chemical Research Laboratory, Teddington, Middlesex, to afford opportunities for viewing recent work in progress there. On Tuesday, September 27, the Laboratory will be open for visits from 2.30 to 5.30 p.m. only, but on Wednesday, September 28, and Thursday, September 29, visits may be made from 10 a.m. to 1 p.m. as well as from 2.30 to 5.30 p.m. Industrial concerns desiring to receive invitations should apply to the Director of the Laboratory, at the above address, not later than August 31, but firms already on the Laboratory's mailing list need not re-apply.

## DIRECT-CURRENT SUPPLY FOR GROUND TESTING OF AIRCRAFT INSTRUMENTS

The General Electric Company, Limited, Kingsway, London, W.C.2, have designed the naturally air-cooled selenium rectifier unit shown in the accompanying illustration for supplying the direct-current necessary for the precision-setting and testing of aircraft instruments on the ground.

It has a three-phase input voltage of 400/440 volts, 50 cycles, and a direct-current output of 10 amperes at 26 to 30 volts, the latter being controlled by a six-position transformer rotary tapping switch. The inherent voltage regulation is 6 per cent. The input is controlled by a switch and fuse and the output connection is made through a shuttered plug and socket, switch and fuse.

The unit, which is mounted on castors and fitted with a pram handle for easy movement, can carry an electronic camera weighing 60 lb. Each of the four castors is provided with a foot-brake. The equipment shown is installed for supplying an aircraft camera in the electronic section of the English Electric Company's Aircraft Division, Warton, near Preston.



**This rectifier unit has been designed to supply the direct current needed for testing aircraft instruments on the ground.**

## A SCIENTIST IN AND OUT OF THE CIVIL SERVICE

In the 1955 Haldane Memorial Lecture at Birkbeck College, which has now been published, Sir Henry Tizard traces the growth of governmental and public interest in science in this country. In the "Free Trade" atmosphere of the last century few people worried about the fact that British manufacturers were falling behind Germany in the application of science to industry. The only significant action at the end of the century was the establishment of the National Physical Laboratory, with an annual grant of £4,000, on the lines of the German Physikalisch-Technische Reichsanstalt.

It was Lord Haldane who was the originator of much of our modern research work on both the defence and civil sides. It was on his advice that a Chemical Research Department was added to Woolwich Arsenal in 1903 and, when he became Secretary of State for War in 1906, he became chairman of the Aerial Navigation Committee which was concerned with balloons for artillery observation. He was later responsible for the change of name of the Balloon Factory at Farnborough to the Army Aircraft Factory, the first official use of the word "aircraft" in the English language. It was the Liberal Government of that time which founded the Development Commission with wide powers of research in 1909, and the Medical Research Committee (now the Medical Research Council) in 1911. The Department of Scientific and Industrial Research did not follow until 1916. A speech which Haldane made in 1903 has a curiously modern ring. Answering the question as to what he would do to overcome the disadvantages of British industry, he said: "I would in the first place begin by adding, in the interests of economy, a million to our estimates for higher education. . . . I would take every step that would interest the manufacturer in the applicatiou of science to his industry . . ." Haldane was also largely responsible (together with Sidney Webb) for the foundation of the Imperial College of Science and Technology, of which Sir Henry Tizard was Rector from 1929 to 1946.

Sir Henry first joined D.S.I.R. in 1920 and he has many interesting things to say about the relations between scientists and administrators. These have greatly improved during recent years, partly as the result of scientists working cheek by jowl with officers of the fighting forces and civil servants during the war, and, afterwards, of the formation of the Defence Policy Research Committee and the Advisory Council on Scientific Policy. Parliament itself has become better educated through the work of the Parliamentary and Scientific Committee.

Sir Henry believes that the number of scientifically trained men entering the administrative civil service is not enough, and that one way of changing this would be to implement the recommendation of the Barlow Committee that suitable members of the scientific civil service should be transferred to the administrative class. In addition, he is of the opinion that a majority of our future administrators should have had a broad scientific education and his suggestion for achieving this is the inclusion of science in courses for degrees similar to Modern Greats at Oxford.

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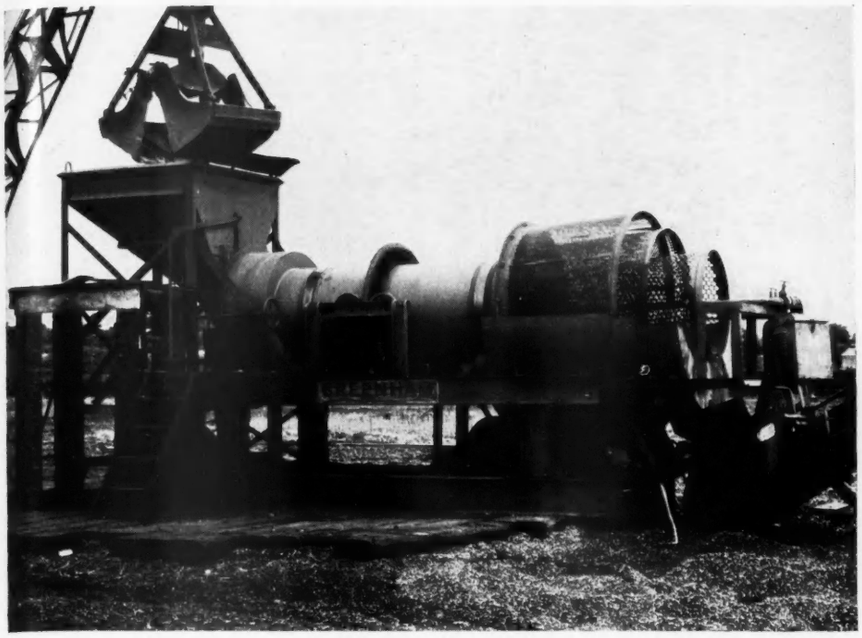
## AIRCRAFT CRASH RESCUE SAW

A. C. Morrison (Engineers), Limited, Loughborough, have developed a portable generating set designed to operate a high-speed aircraft rescue saw.

The power unit is a Coventry Victor MA2 twin-cylinder air-cooled petrol engine developing 6 brake horse-power at 3,000 r.p.m. directly coupled to a 3-kVA 110-volt 50-cycle, single-phase 3,000 r.p.m. self-exciting self-regulating alternator, operating a Black and Decker 12-in. portable rescue saw.



**The economic need to recover and clean spent ballast from the permanent way has led British Railways to instal this plant which will handle 500 tons of dirty stone per week.**

## RECOVERY OF TRACK BALLAST

### *Cleaning Plant on British Railways*

The modern railway permanent way requires a good foundation of clean, well-consolidated and well-placed ballast under the sleepers, and the means have had to be found for cleaning and screening for re-use the spent ballast removed from the track. This spent ballast is generally fouled by clay and vegetable matter (from the sub-grade), oil, grease and ashes (from locomotives) and spillage (trains generally). In some cases this fouling can be so heavy that screening by the ballast-cleaning machine at site is not practicable.

Plant, such as that shown in the accompanying illustration, has now been installed by the London Midland Region of British Railways to recover and re-grade this spent stone in a condition equal to that of newly quarried material. Use is made of a large volume of water for cleansing purposes, while the stone is simultaneously agitated and screened. The illustration shows the plant which, on hire from Greenham Plant Hire, Limited, Isleworth, Middlesex, has been assembled on a site at Grovesbury Tip, Leighton Buzzard. An excavator, fitted with a grab, unloads the dirty aggregate from the incoming wagons into the hopper of the washing and screening machine; water is sprayed continuously over the stone and this commences the process of loosening the coating of dirt. The feed from the hopper is then directed into the contra-flow washing cylinder to which the water is supplied under pressure.

During this stage the greater amount of the dirt and grease is removed before the stone overspills into the revolving cylindrical screens where a final spraying with water removes the remaining traces of unwanted material. The cleaned ballast is segregated into various grades by the screens and is delivered by chutes and elevators either to waiting wagons or to stockpiles. The water for the plant is obtained by pumping and after use is allowed to percolate back to the pond via tipped material which acts as a filter. Three men operate the plant which is able to handle 500 tons of dirty ballast per week and experience shows that the stone retains its desirable angularity after treatment.

# GRINDING IMPROVED BY VIBRATION

## UNEXPECTED RESULTS OF AMERICAN TESTS

Professor L. V. Colwell, of the Department of Production Engineering, College of Engineering, University of Michigan, U.S.A., described some experiments to determine the effects of high-frequency vibration on grinding, in a paper read at a meeting of the American Society of Mechanical Engineers at Boston, Mass., U.S.A., on June 19 to 23, 1955. Some interesting conclusions were reached, and it was shown that there is a possibility of applying high-frequency and even ultrasonic vibrations to selected operations to improve the grinding process. A summary of the paper is given below.

Vibrations of the strong resonant type, which cause chatter and may result in spoilt work, have been virtually eliminated, but there is evidence to show that vibration problems still exist. Skilled operators of grinding machines will use sounds from the grinding zone to guide them in their work, and these sounds are created by vibrations which may be in the wheel, the work or the spindle, or in some combination of all three. The investigations were confined to vibrations in the range 10 to 18 kilocycles per second, and were carried out on a standard 8 in. by 24 in. reciprocating-table surface grinder. A preliminary study established the fact that the amplitude of the vibrations occurring naturally in the grinder did not at any time exceed 0·002 in. to 0·003 in., and that the machine could be considered substantially rigid. Work specimens were mounted on top of an electrical transducer consisting of a stack of laminations of pure nickel sheets 0·005 in. thick, wound with copper wire to form a coil. Alternating current applied to the coil caused the nickel laminations to expand and contract alternately, and so to give vibratory motion to the two ends of the stack of laminations. Specimens were vibrated at amplitudes up to approximately 0·001 in. at frequencies ranging from 10 to 18 kcs. per second.

Preliminary tests gave some unexpected results. With a range of approximately 0·001 in. at 10 to 11 kcs. per second, a cut of 0·002 in. and a cross-feed of 0·050 in. on hardened steel, the surface roughness was reduced from 40 to 16 micro-inches, or 60 per cent., as compared with a similar cut without vibration. This effect persisted at shallower cuts. It was also seen, by microscopic examination of the grinding swarf, and by visual observation of the spark stream, that lower temperatures occurred as a result of induced vibration. To remove any doubts about the results of the preliminary tests, numerous additional tests were made, conditions being varied considerably. These tests confirmed the initial results, and showed that the apparent temperature reduction also had an effect on residual stresses in the work. It was observed, in addition, that the rate of wheel breakdown appeared to be more rapid when vibration was induced.

Further tests were therefore carried out to confirm the apparant reduction in temperature, and to determine the effect on grinding ratio, or ratio between the volumes of metal and abrasive removed. The temperature effect was observed by visual examination of the swarf, and by means of thermocouples embedded in the work. Under the same conditions, but with and without vibration, temperatures of 225 deg. F. and 475 deg. F. were recorded, thus proving that vibration caused lower temperatures at the point of grinding. Confirmation of this fact was obtained by collecting swarf in glass beakers at a constant distance from the wheel, when it was seen that in the case of grinding without vibration, particles of metal were fused to the side and bottom of the beaker. When vibration was induced such fusing of particles was almost entirely absent. In view of the fact that with vibrated grinding the temperatures were lower, it was expected that there would be a significant difference in residual stress in the work as between the two methods of grinding, and this was confirmed by further experiments. As an example, it was found that tungsten-carbide tips could be ground with an aluminium-oxide wheel, which is not recommended for this purpose, provided that the work was vibrated in the way described, and that under these conditions no thermal cracks were produced.

The conclusion drawn from the experiments was that high-frequency vibration can produce desirable results in grinding, but it was pointed out that more work needs to be done to clarify the mechanism of its effectiveness. Still more work will be needed in order to learn how to apply the principle to industrial grinding.

* * *

## "LOADMASTER" MINIATURE CIRCUIT-BREAKER

The "Loadmaster" miniature circuit-breaker is produced by Messrs. Dorman and Smith, Limited, Ordsal Electrical Works, Manchester, 5, for the protection of circuits with carrying capacities up to 30 amperes at 250 volts alternating current. With it is associated a range of distribution boards for surface or flush mounting giving two, four, eight and twelve ways.

The breaker is provided with silver-tungsten contacts to give a long life and their cleanliness is ensured by a wiping action. The high contact pressure ensures that the temperature rise does not exceed 25 deg. C. when carrying 30 amperes. Tripping is effected thermally on overload and magnetically under fault conditions, the breaking mechanism being trip-free. Wiring is facilitated by the use of reversible screw clamp connectors and the equipment can be fixed either flush or on the surface.

The rupturing capacity at 250 volts alternating current and 0·75 power factor is 3,000 amperes. On test the circuit-breaker has withstood 10,000 tripping and 50,000 switching operations.

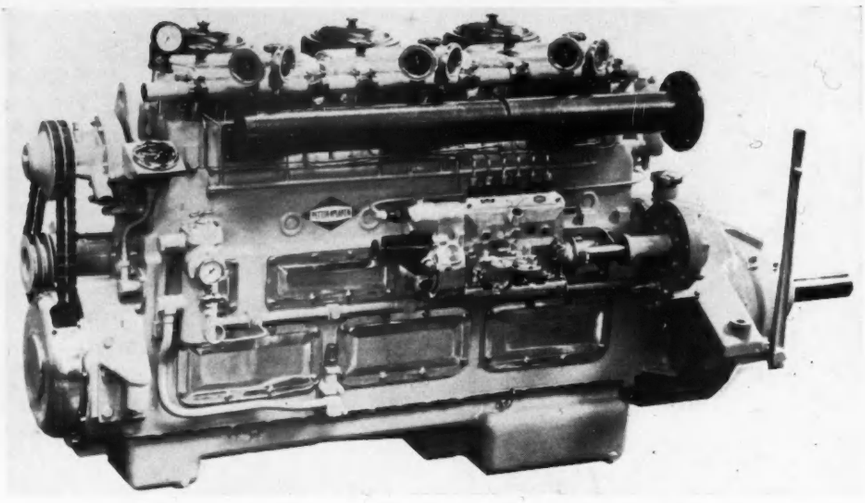


**Fig. 1 The LE range of engines is designed for simplicity and ease of maintenance. The LE6 (normally-aspirated) shown here will develop 180 b.h.p. at 1,800 r.p.m.**

# INDUSTRIAL DIESEL ENGINES

## APPLICATIONS FOR EARTH-MOVING EQUIPMENT AND GENERATOR SETS

A Diesel engine designed to compete in the medium-power range, and in particular for use in earth-moving equipment and air-compressors, has been announced by J. and H. McLaren Limited, Airedale Works, Leeds, 10. Prototype models have passed their tests successfully and it is intended that full production shall begin in 1956. Two sizes are made, a four-cylinder and a six-cylinder, and both can be supplied either normally-aspirated or supercharged. With a bore and stroke of 5⅛ in. and 6 in. respectively, at 1,800 r.p.m. the 12-hour ratings of the engines are 120 and 180 brake horse-power respectively; the Root's-type supercharger increases both these figures by 30 per cent.

The new engines are to be known as the LE range and are conventional in design. Simplicity and ease of maintenance have been the guiding principles. The overall lengths are less than other engines of comparable output and the widths are approximately the same. This will enable them to be used as direct replacements in earth-moving equipment. The addition of the supercharger does not increase the dimensions and an LE 6 thus fitted is shown in Fig. 2; a normally-aspirated version, fitted with torque converter and clutch, is illustrated in Fig. 1. Although a cast-iron cylinder block has been used, the power-to-weight ratio is good, being 20 lb. per brake horse-power for the four-cylinder version and 17·8 lb. for the six-cylinder type (reckoned on the dry weight) for normally-aspirated engines.

A monobloc cast-iron crankcase has been used in the engines, with wet liners. The latter are cast and their lower water-seal is formed by a vertical nip on a rubber sealing ring. Access doors allow inspection of the crankshaft and servicing of the big ends. Other doors enable the camshaft and followers to be reached. The pistons can be withdrawn through the cylinder, for which purpose the big-ends are scarfed at 45 deg. The crankshaft is a forging of high-tensile steel and runs in thin-wall copper-lead bearings. The big-end bearings are similar. The crankshaft is underslung but it is possible to service the main bearings without moving either the bell housing or the shaft. A small damper is fitted to reduce torsional vibrations.

The cylinder heads are in pairs, and are also of high-duty cast iron. There is one inlet and one exhaust valve for each cylinder, since the engines run on the four-stroke cycle. Between the valves is the injector. The rocker gear is enclosed by a cover held by a hand-nut, and is mounted on studs additional to those which are used to hold the cylinder head. The nuts fixing the latter can therefore be tightened without disturbing the valve gear. In the normally-aspirated engine, each pair of cylinders draws its air through a separate air filter.

The piston is of low-expansion light alloy, fitted with a chromium-faced top ring, two other compression rings and two oil-control rings. The gudgeon pin is fully floating. A forged high-tensile steel connecting rod of H section is used. The crown of the piston is dished to form the combustion chamber. Fuel is supplied to the injector by a camshaft pump driven from the timing train. A diaphragm lift pump draws fuel from the tank. On the pre-production models demonstrated, Bryce Berger equipment was used, but other makes can be fitted if required. A point in favour of the Bryce Berger equipment is that since they belong to the Brush group, as also do McLarens, one service agent can cover the complete engine.

An unusual feature incorporated in these engines is that the timing-gear train is driven from and mounted at the flywheel end of the crankshaft. Straight spur gears are used throughout the train. Easy accessibility has been maintained, as the gears can be inspected and the timing checked by removing the hood of the fuel-pump drive. It is also possible to remove the camshaft gearwheel and the camshaft itself without disturbing the bell housing or the flywheel, or uncoupling the driven machine. The governor is mounted at the end of the fuel pump and has characteristics according to B.S. 649/1949 for the 1,500 and 1,800 r.p.m. applications. Alternatively, a variable governor can be fitted which gives fine regulation of any speed between 600 and 1,800 r.p.m.

Forced lubrication for the bearings, the timing train and the valve gear is supplied by a gear pump drawing oil from the sump through a fine gauze. The oil is delivered to the distribution gallery through a plate-type filter, of 0·0015-in. mesh, and an oil cooler. Reduced pressure is used for the feed to the valve gear and the gear train. Provision has also been made for operating the engines with a dry sump—a condition required for earth-moving equipment which is frequently tilted to an angle up to 30 deg. Water for cooling is circulated by a pump with a balanced impeller driven from the free end of the crankshaft by a belt. The same belt also drives the dynamo. The sealing gland of the water pump is of the self-adjusting type and the spindle runs in Neoprene "sealed" ball bearings. From the pump the water is fed into the top of the cylinder jacket branches leading to the head. In the latter, deflectors are arranged to guide the flow around the atomisers. Outlet water from the top of the cylinder heads is collected in a manifold and taken to a radiator or cooling tank.

To enable both engines to be used in chassis, steps have been taken to reduce vibration. For this, the crankshafts of both are fitted with balance weights, eliminating couples. The mounting of the timing-gear train at the flywheel end also makes for even running. Performance curves for the LE6, normally aspirated, are given in Fig. 3; although the present rating of these engines is only up to 1,800 r.p.m., it is considered probable that this will be raised to 2,000 r.p.m. or possibly to 2,200 r.p.m. These higher speeds would be for traction applications. As stated above, the Root's-type supercharger gives a power increase of 30 per cent., but tests are in progress using a turbo-charger which will raise this to 50 per cent.

As has been mentioned earlier, the main applications for which these engines have been designed are earth-moving equipment, air-compressors and the like. They can also be used

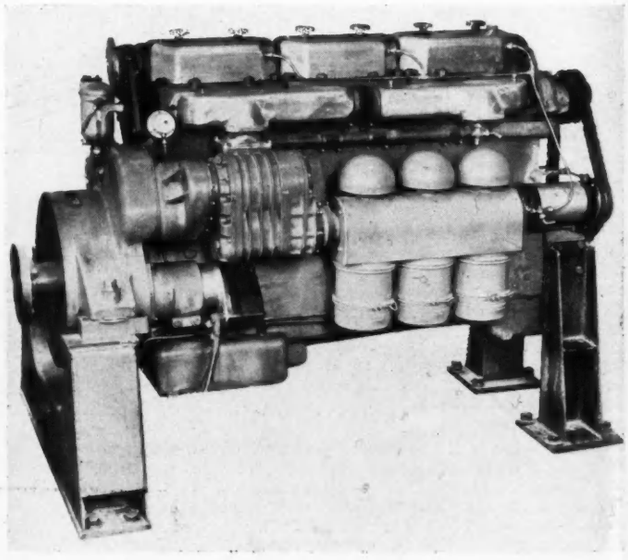


**Fig. 2. By the addition of a supercharger, the power output can be increased 30 per cent. without increasing the overall dimensions.**

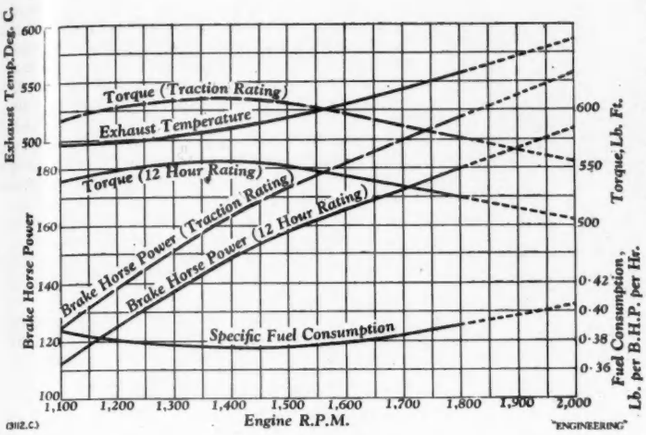



**Fig. 3 Performance curves for the LE6 normally-aspirated engine. For traction conditions it is probable that the maximum speed will be raised to 2,200 r.p.m.**

in generating sets and for high-speed marine work. To make the engines interchangeable, only unified threads have been used and S.A.E. mountings employed. American electrical equipment can also be fitted. For compressor applications, the fact that the supercharger does not increase the overall dimensions permits both types of engine to be mounted on the same chassis. The LE6 engine will drive a rotary compressor handling 600 cub. ft. of free air per minute at sea level, and the addition of the supercharger will maintain this performance up to altitudes of about 12,000 ft. For generating sets, a special light-weight generator is being developed for flange-mounting on the engine. An auxiliary drive of up to one-third the engine output may be taken through a clutch at the free end. Overall dimensions of the LE6 are approximately 72¾ in. long by 35¼ in. wide by 44 in. high, and the dry weight is 3,200 lb. normally aspirated. The LE4 is 16 in. shorter and weighs 2,400 lb.

# MOBILE FURNACE FOR BRIGHT ANNEALING

## CONTINUOUS OPERATION ACHIEVED

The latest addition to the bright-annealing plant in use at the steel wire works of Bruntons (Musselburgh), Limited, Musselburgh, Midlothian, is a mobile furnace mounted on four wheels, travelling on rails to any one of four working positions arranged in a straight line on the shop floor. The installation, a general view of which is shown below, has been designed and supplied by the General Electric Company, Limited. The furnace is used to bright-anneal lengths of cold-rolled mild and other carbon-steel strips and has doors at each end. The furnace is driven along its track by a chain and sprocket arrangement through reduction gears from a hand-winding unit at the side of the furnace body; it can be moved by a single operator. At each of the four working positions is a furnace base with a refractory hearth capable of supporting a charge of steel strip in lengths up to 7 ft., stacked to a depth of 2 ft. and a width of 2 ft. To allow an adequate heat transfer to the base of a charge, the hearth has a chequered formation. For bright-annealing, the charge is sealed within a heat-resisting steel hood, the projecting flanges of which seat in sand channels round the base.

The adoption of four working positions makes possible a continuous cycle of operations, comprising the loading of a furnace base, the purging of a new charge with a protective atmosphere, the heating and cooling of the charge, and its unloading.

The furnace is heated by means of heavy-gauge nickel-chromium alloy ribbon elements arranged in sinuous form and mounted in the roof, the side walls and the doors. To minimise heat losses the doors are clamped into position against the end plates at each working position; moreover, the doors and furnace body, like the sealing hoods, have down-projecting angles seating in sand channels round each base. The doors are suitably counterbalanced to permit of easy raising and lowering by means of an endless chain from one side of the furnace track.

The protective-atmosphere pipework and electric power lines are housed within the furnace track. Electrical contacts are made automatically when the furnace is moved to a base, a signal lamp providing a visual indication that the furnace is accurately positioned. An aural alarm guards against the accidental movement of the furnace before the control circuit connections are broken, and door switches ensure that all current to the furnace is broken immediately either door is raised. Temperatures of up to 850 deg. C. may be obtained, and the furnace is fitted with automatic temperature-control gear. Protection from accidental overheating during operation is secured by means of an excess-temperature fuse.

Alongside the new installation are situated vertical cylindrical furnaces also supplied by the General Electric Company. These have been in use for many years for the bright-annealing of steel strip in coils.

**Operator lowering the sealing hood over a charge of cold-rolled sheet strip prior to bright-annealing treatment in the mobile-furnace plant installed by the General Electric Company, Limited, at the steel wire works of Bruntons (Musselburgh) Limited.**

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## LAUNCHES AND TRIAL TRIPS

M.S. "RIKKE SKOU."—Single-screw cargo vessel, with accommodation for twelve passengers, built and engined by the Elsinore Shipbuilding and Engineering Co., Ltd., Elsinore, Denmark, for Ove Skou, Copenhagen, Denmark. Main dimensions: 416 ft. 9 in. by 56 ft. 6 in. by 33 ft.; deadweight capacity, about 7,000 tons on a mean draught of 23 ft. 9 in. Elsinore-B. and W. eight-cylinder oil engine, developing 7,300 i.h.p. Service speed, 17 knots. Launch, July 29.

S.S. "TYNEMOUTH."—Single-screw cargo vessel, built and engined by Smith's Dock Co., Ltd., South Bank-on-Tees, for the Burnett Steamship Co., Ltd., Newcastle-upon-Tyne. Main dimensions: 350 ft. between perpendiculars by 51 ft. by 25 ft. 3 in. to main deck; deadweight capacity, 5,505 tons on a draught of 21 ft. 0⅛ in. Triple-expansion steam engine, working in conjunction with a Bauer-Wach exhaust turbine, and developing 1,550 i.h.p. at 90 r.p.m. in service. Steam supplied by two multitubular boilers burning oil fuel only. Speed on trial, about 12½ knots. Delivered, August 5.

S.S. "CASTILIAN."—Single-screw cargo vessel, built by Alexander Stephen and Sons, Ltd., Glasgow, for the Mediterranean service of the Westcott and Laurance Line Ltd., London, E.C.3. Main dimensions: 350 ft. 6 in. between perpendiculars by 53 ft. by 32 ft. 9 in. to shelter deck; gross tonnage, 3,802; deadweight capacity, about 5,440 tons. Triple-expansion direct-acting steam engine, working in conjunction with a Bauer-Wach exhaust turbine; the steam engine being constructed at the Central Marine Engine Works of William Gray & Co., Ltd., West Hartlepool, and the turbine by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne. Steam supplied by three Scotch oil-burning boilers, constructed by John G. Kincaid & Co., Ltd., Greenock. Delivered, August 8.

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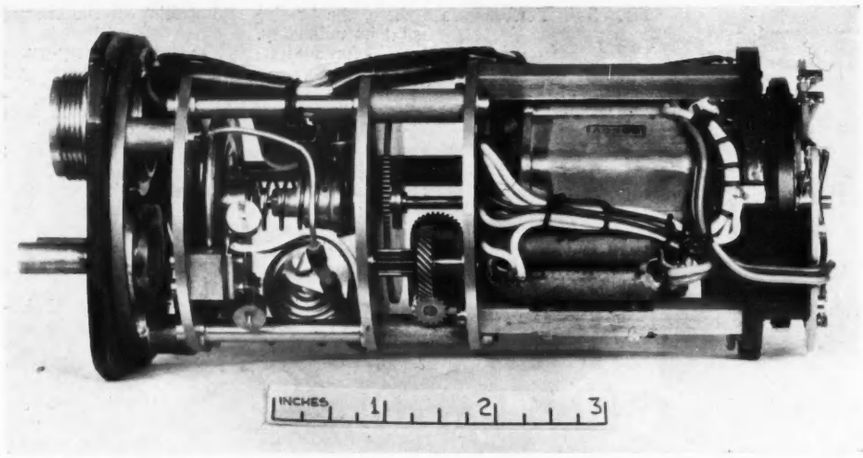
## EASY-READING MICROMETER

The confusion that can arise in reading a micrometer, not only for apprentices but also for men who only use one occasionally, has been largely overcome by an improved micrometer marketed in this country by Production Promotion, 94 Camden-road, London, N.W.1. Thousandths of an inch are read directly from a figure which appears in an aperture, and tenths of a "thou." are read from a normal vernier on a barrel of large diameter.




**In the Kelvin and Hughes airspeed sensing unit, the signals from the airspeed-measuring capsule, which is balanced against a compression spring, cause a servo-motor to bring into operation a two-tone audible warning system which tells the pilot whether his speed is too high, too low, or just right for landing.**

# AIRSPEED SENSING UNIT WITH AUDIBLE INDICATION

## SIMPLIFYING AIRCRAFT LANDING TECHNIQUE

Earlier this year the Admiralty announced the development of a new audible system of airspeed indication for assisting naval pilots in making deck landings, primarily for use with the mirror deck-landing aid. The general principle of the Audio system, which was devised by Surgeon-Commander Ellis and Mr. A. Burrows of the Institute of Aviation Medicine, Farnborough, and the experimental studies which led up to it, were described in the March 18 issue of ENGINEERING, and it may be recalled that the apparatus comprises two parts—the audio signal generator and the airspeed sensing unit. The Admiralty approached two firms for the design of these units—Seaton Craige Limited, Park Royal, London, for the audio signal generator, and Kelvin and Hughes Limited, Basingstoke, for the airspeed sensing unit. The latter component, now in production, is the subject of this article.

### WHAT THE PILOT HEARS

Before giving the details of the Kelvin and Hughes airspeed-sensing unit, we should like to describe what the pilot hears in his headphones as he comes into land. The signals are only heard when the aircraft is below the speed for lowering undercarriage and flaps. At this speed, a high-pitched intermittent sound becomes audible. As he reduces speed, at a certain point the frequency of the high-pitched tone is stepped up, and when the speed is lowered to the maximum safe landing speed, the note becomes continuous. This high-pitched continuous sound is heard throughout the safe landing-speed range (the upper end of which is limited by the loads imposed on the arrester gear, and the lower by consideration of aircraft controllability). Halfway through the safe landing-speed range—at the speed considered ideal for landing—a new sound is heard superimposed on the high-pitched continuous tone, an intermittent rough low-pitched buzz. When the speed falls below the safe limit, the intermittent buzz continues but the high-pitched tone is no longer heard.

This gives to the pilot—even if he is tone-deaf—a clear-cut indication of when he has attained the desired landing speed, without distracting his eyes from the deck ahead, as has hitherto been the case when he was dependent on a visual airspeed indication. The audio system also provides some idea of the rate at which his speed is changing. Although primarily developed for carrier-borne aircraft, it seems likely that the audio system of airspeed indication can provide added landing safety for any aircraft with a high landing speed.

### FORCE-BALANCED CAPSULE OPERATES SERVO SYSTEM

The audio programme required the switching of two separate audio tones and the use of an intermittent frequency of 2 to 5 cycles per second to signify movement to and from the selected safe zone. The available power from a conventional airspeed indicator system which relies upon the deflection of a capsule to provide the indication, was insufficient, and it was decided that a servo indicator unit was essential.

The principle adopted was the well-known force-balance system, in which the compression force from a spring is balanced against the force output from a capsule, this force being proportional to the difference between the pitot and static pressures, i.e., to the square of the airspeed. The adoption of this technique enables most of the difficulties of design associated with the capsule to be avoided. By suitable design, the output characteristic is that of the spring which may be quite linear and, therefore, predictable. This enables a programme unit of fixed dimensions to be mounted on the output shaft, the power of which is related to the type of servo motor used, not to the pitot pressure. Moreover, the discrimination can be made quite high and the hysteresis normally associated with a capsule completely eliminated.

The special requirements for the airspeed sensing unit are an accuracy of $\frac{1}{2}$ knot at the critical point and the boundaries of the adjacent 5-knot zone, with a full-range movement of 25 knots, later extended to 40 knots. The unit must withstand high overload speeds of 650 knots. Two-tone channels are used and are connected, with an associated potentiometer, to the sound generator unit and a chopper motor. Either tone or combination, with appropriate intermittent chopping is fed directly through the intercommunication receiver to the pilot. His panel control is merely for sound volume, together with a changeover switch which, in effect, shifts the whole programme up 5 knots in order to cope with heavier landing weights. The airspeed sensing unit automatically switches itself on at the appropriate pre-set low airspeed and cuts out at the end of the normal programme. A subsidiary miniature airspeed switch incorporated in the unit enables one of the channels to be extended as high as required, but the chopping rate remains constant on this extended zone.

The prototype instrument was conceived and constructed within one month and was immediately used for flight tests, later being taken on carrier trials. No unserviceability of any sort was experienced although various adjustments and improvements were incorporated as the flight technique was developed. The model turned out to be rather more heavy and bulky than an aircraft instrument of this type should be, but it proved to be a sound flexible design capable of considerable development and its basic features were incorporated in the production model.

### THE PRODUCTION UNIT

This instrument utilises a standard differential pressure capsule operating against a helical compression spring, the out-of-balance condition being obtained by the opening of a pair of contacts, one of which is on a lever bearing on the centre of the capsule. The spring, the rate of which can be adjusted, is compressed by means of a lead-screw mechanism, the movement of which is limited to 360 deg., driven by a small permanent-magnet motor through a gear train. The balance contacts operate a changeover relay of approved design for this motor, which continually hunts around the balance point. The lead-screw shaft extends to the rear of the unit and there carries a brush, operating over a fixed circular potentiometer and a circular face plate commutator rotating against fixed contacts. The appropriate programme is set on concentric arcs on the commutator, which is of the moulded type. One arc is used for switching the unit on over the required range of airspeed. In this version the contacts are in pairs for high- and low-airspeed programme settings.

The unit has been fitted into a standard $3\frac{1}{4}$ in. S.A.E. case with appropriate electrical plug and nipple connections at the "bezel" end. Although, as can be seen from the illustration, the available space has been most economically used, the instrument has been designed for flexibility, since it is envisaged that the audio signal system might be modified considerably during service trials or for purposes other than deck landing, and that different aircraft might require different programme settings. Apart from the available adjustments in the capsule and spring in the present model, the changes may be rung on the programme commutator and contacts since both fittings are easily replaceable. The direct-current servo-motor system has been retained since extended laboratory tests have shown that an instrument life of at least 250 hours is possible without change in calibration or electrical breakdown; since the instrument is only used on the approach, this should represent some thousands of aircraft flying hours. Moreover, the direct-current system dispenses with the need for additional load on the present aircraft alternating-current supply and also with the necessary servo amplifier. An alternating-current system has, however, been satisfactorily tested on this equipment in case the circumstances should arise for its incorporation. The present instrument has a zero shift adjustment available through a removable plug which will enable the unit to be adjusted up to 5 knots to the individual pilots' requirements—particularly for Service trial purposes.

The airspeed sensing unit is believed to be the first direct application of a servo-following airspeed system in operational aircraft. It is sufficiently adaptable and unobtrusive to be used for a variety of applications, e.g., for direct remote indication, for use in artificial-feel control, for automatic controls and in conjunction with other servo-following units of a similar type for computing normal aircraft conditions. Multi-turn outputs may be incorporated and sufficient power is available to use any known form of transmission, including that of digital

information. The use of the force-balance principle frees the designer from the limitations normally associated with capsule instruments, to give a predictable scale shape which may be distorted at will and presented in what ever manner is convenient, and at the same time has a much higher discrimination and absence of hysteresis. Sufficient testing has been carried out to indicate that it may be simple, light and reliable.

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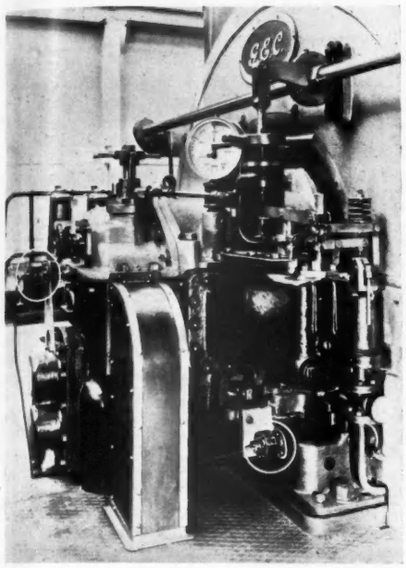


**The transducer on the right is used to measure the expansion of the turbine casing relative to the floor, and that on the left the expansion of the shaft relative to the casing.**

## TURBINE SHAFT EXPANSION

### *Measurements made with Transducer Equipment*

The electro-magnetic transducer system developed by Salford Electrical Instruments, Limited, Salford, Lancashire, has proved particularly applicable to the measurement of turbine expansion characteristics. It can be used to measure both the absolute longitudinal expansion of the turbine casing and, in certain cases (for example, with General Electric Company's two-casing high-output sets), the differential axial expansion of the shaft in relation to the casing. When used in conjunction with a recorder, the transducer system can, therefore, provide a record of the expansion characteristics of a turbine during, for example, its running-up period, and may even enable this period to be reduced.

A typical transducer set-up for measurements of this kind is shown in the illustration. The turbo-generator is a 30-MW General Electric set, and two transducers have been used. The one on the right is mounted on a bracket attached to the turbine casing so that the measuring stylus bears directly on the pedestal supporting the turbine. When the temperature rises and the casing expands, the body of the measuring head, being attached to the casing, moves longitudinally away from the pedestal. The spring-loaded stylus continues, however, to bear against the pedestal and the transducer system converts the resulting internal displacement within the measuring head into a variation in magnetic flux, which is reproduced as a recording on an instrument reading on the control panel.

The other transducer measuring head is mounted on the end of the casing so that the stylus bears directly on the end of the turbine shaft. It therefore records the differential axial expansion of the shaft in relation to the casing.

Several features make the transducer system particularly suitable for this application. For example, the measuring head is extremely compact and can easily be mounted on a set. Also, the system is basically simple in operation. The measuring head merely comprises a magnetic core mounted between two coils on a spring-loaded shaft. Any movement of the stylus on the end of this shaft displaces the magnetic core and causes a variation in the magnetic flux. The head is connected to the associated recorder/controller or indicating instrument in such a way that the pointer takes up a position in which this flux variation is balanced out. Mechanical displacements of less than 0·001 in. can be measured directly in this way and no electronic valves, barretters or other intricate electronic gear is used.

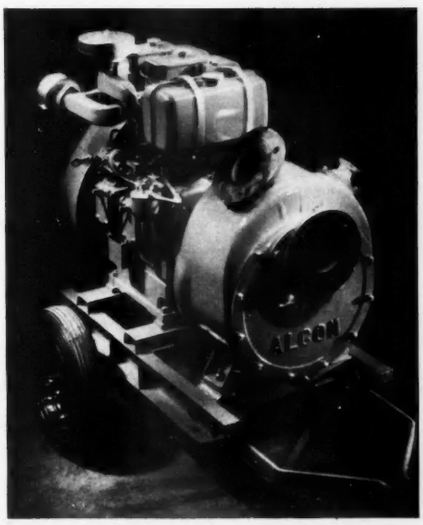
* * *

## CENTRIFUGAL PUMP

The most recent to be added to the range of products made by Arthur Lyon and Company (Engineers), Limited, Stamford, Lincolnshire, is the Alcon 4-in. centrifugal pump driven by a Petter AVA 2 air-cooled Diesel engine. The delivery is 30,000 gallons per hour. One of these units mounted on a two-wheel trailer is shown in the illustration below.

The engine is hand started and develops 10 h.p. at 1,500 r.p.m. The pump is spigoted directly to the crankcase with the impeller bolted to an extension of the crankshaft. It is self-primed by water recirculation. The direction of flow is such that the bottom of the pump body is continually scoured, thereby preventing the accumulation of solid matter. A rubber non-return valve fitted to the inlet ensures re-priming even when the pump is working on "snore." The impeller is of the three-bladed open type and is able to handle solids up to ⅜ in. in diameter. A wearing plate is fitted in front of the impeller, which is easily replaced by removing the front cover. It is not necessary to remove the main body of the pump to replace either the seat, the impeller or the wearing plate.

All metal parts of the pump are made of close-grained cast iron, but other materials can be used for special conditions. All mating faces are sealed with rubber O-rings. The running seal is of the mechanical face-type using as standard a cast-iron counterface, with a carbon running face and Hycar rubber sealing bellows. The mating faces are ground optically flat before assembly.




**The Alcon 4-in. pump is driven by a 10-h.p. Diesel engine and is capable of handling solids in suspension up to ⅜ in. in diameter.**

**The Saturn II scrubs a strip 17 in. wide at each pass leaving the floor almost dry behind it. It has a maximum speed of 2 m.p.h.**

## SELF-PROPELLED FLOOR SCRUBBER

### *Quick Cleansing of Large Areas*

What is believed to be the first self-propelled machine to be made in this country for the large-scale cleaning of factory floors has now been introduced by the Cowland floor maintenance machine division of Matling Limited, Park-lane, Wolverhampton. Known as the Saturn II, it is shown in the accompanying illustration.

The machine is both self-propelled and self-contained, for it is battery-driven and carries a tank for the clean water and another to which the dirty water is returned. It is stated that the floor is dry within a few seconds of the passage of the machine. The brushes clean a strip 17 in. wide at each pass, and the trailing squeegee which follows them is 22 in. wide. The machine itself also has an overall width of 22 in. with a length of 64 in. It stands 42 in. high.

A constant-speed 24-volt motor, supplied from a 175-ampere-hour Exide-Ironclad battery, drives the single front wheel through a clutch and gearbox. The latter allows three forward speeds of ½, 1 and 2 m.p.h., and one reverse. The clutch is a heavy-duty single-plate model. The operator sits astride, as in the illustration, with all his controls to hand. The clutch and brake levers are mounted on the steering handlebars.

The main frame of the machine is a light-alloy casting on which the various components are mounted. The brushes, which are driven by a 1-h.p. motor running at 2,000 r.p.m., are arranged in the intermeshing pattern common to all Matling machines. Their shape is that of a four-point star with a cut-out centre; the intermeshing ensures that the whole strip is scrubbed and the cut-out centres prevent clogging and allow a degree of self cleaning. The brushes are held in position by spring-loaded sockets and can easily be changed when the hydraulic jacks are used to lift the machine.

A mixture of water and detergent is fed by gravity from a 5-gallon tank and distributed over the floor by a sprinkler. The rate of feed is such that a tank-full lasts for 30 minutes, during which time an area varying between 2,250 and 5,400 sq. ft. can be covered, depending on the speed of working. After the brushes have passed, the dirty water is caught by a squeegee, to which are fitted suction pipes. A motor-driven air extractor, running at 14,000 r.p.m. then draws the dirty water into the second tank. It is possible to scrub within 6 in. of a wall or other obstruction, and in certain cases where visibility is good, to within 3 in. A model with a 15-gallon tank instead of the standard 5-gallon one, is also available.

# TEST BENCH FOR AIRCRAFT GENERATORS

The accompanying illustration shows a bench, which has been designed by Arthur Lyon and Company (Engineers), Limited, Stamford, Lincolnshire, for testing direct-current generators with outputs up to 6 kW at 28 volts and alternators with outputs up to 1·2 kVA at 80 to 115 volts, while they are installed on aircraft in service.

The bench consists of a mild-steel angle framework incorporating a hinged seating on which the main driving motor is mounted. This motor, which was manufactured by the British Thomson-Houston Company, Limited, Rugby, is of the three-phase six-pole variable-speed commutator type and has a maximum output of 20 h.p. when running at 1,700 r.p.m. It is designed for connection to a 415-volt circuit and drives a countershaft in the centre of the bench through a V-pulley and belts. This countershaft is carried in ball bearings, mounted in brackets on the centre top plate of the main frame, and terminates at the front of the bench in a half coupling, which is arranged to mate with a Silentbloc coupling. Connection is made from this coupling to one of two double-helical gearboxes with fixed ratios of 2 to 1 and 1 to 1 respectively. They can, however, also be arranged to give final shaft speed ranges of from 300 to 5,000 or 6,000 to 10,000 r.p.m.

A table, which can be raised or lowered by a handwheel is mounted in the centre front of the bench in line with the output coupling on the gearbox and can be locked in position after it has been accurately aligned to suit a particular generator. The top of this table is slotted to accommodate the spigot and bolts of the brackets on which the generator under test is mounted. The generator is cooled by air, which is supplied from an electrically-driven blower in the base of the bench through a flexible tube.

### OPERATIONAL DETAILS

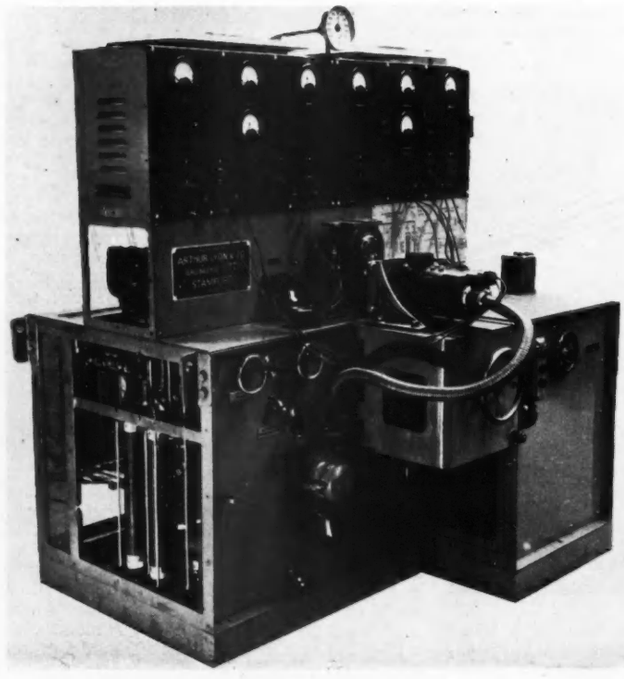
The main motor is started, stopped and reversed by push buttons and its speed is controlled by a handwheel which is accessible from the front of the bench. The push-button switches, which were supplied by the Igranic Electric Company, Limited, Bedford, control an automatic direct-on reversing type contactor starter which was manufactured by the Electrical Apparatus Company, Limited, St. Albans. This starter is calibrated for 15-h.p. operation and is installed in the upper frame of the bench above the motor. It may be pointed out that as the motor has a constant torque characteristic, a machine with an output of 20 h.p. was selected to provide sufficient power at low and medium speeds. The maximum output is, however, limited to 15 h.p. and the starter has been designed accordingly. The motor can be isolated from the mains by a triple pole switch, which is mounted at the right-hand side of the bench.

### DIRECT-CURRENT TEST PANEL

The test panel for direct-current generators is placed at the left of the upper frame of the bench and carries apparatus for measuring and controlling the output of the aircraft generator and its shunt field current. A third circuit enables the charging and discharge current of a battery to be measured while a generator and/or cut-out is under test. The test load is provided by resistances in the base of the bench, one of which has a fixed value to limit the load, while the other, with which it is connected in series, can be varied to give loads up to 100 amperes at 28 volts by operating a handwheel on the front of the bench. There are two other fixed resistances with current capacities of 100 amperes at 28 volts which are connected in series and are controlled by a rotary switch.

The panel for alternator testing is on the right of the upper frame of the bench and comprises apparatus for controlling and measuring the direct-current input to the field and the output of the alternator. As in the case of the direct-current panel both fixed and variable resistances are provided the latter enabling loads up to 20 amperes at 80 to 115 volts and frequencies from 1,000 to 3,000 to be obtained by operating a handwheel at the front of the bench.

The main wiring is carried out in polyvinyl chloride or vulcanised rubber insulated cable, which is laid in steel conduit. The connections to the main motor are enclosed in flexible conduit to allow for the movement of the hinged seating. The wiring on the test panels is insulated by polyvinyl chloride and rubber, while that leading to the load resistances is covered in a non-hygroscopic heat-resisting material.



**Test bench for aircraft engine-driven direct-current generators and alternators.**

* * *

## PADDLE TUGS FOR H.M. DOCKYARDS

### *To be Fitted with Diesel-Electric Main Drives*

It has been found by experience that paddle-driven tugs provide the most suitable means of moving aircraft carriers and other large warships through dock entrances and in the confined waters of dockyard basins. The Admiralty has accordingly decided upon the construction of a series of seven Diesel-electric paddle tugs for use in H.M. Dockyards. An order for two of these vessels has been placed with William Simons and Company, Limited, Renfrew, and for two more with Yarrow and Company, Limited, Scotstoun. The two last mentioned will be named Director and Dexterous, respectively, and their construction is due to be commenced very shortly.

Though intended primarily for harbour work, the tugs will be constructed under special survey to Lloyd's class 100 A1 for towing and salvage services, including assignment of the loadline, so as to enable them to put to sea when required. Accommodation, lighting, signalling apparatus, and life-saving equipment will be constructed to the requirements of the Ministry of Transport and Civil Aviation. The vessels will have an overall length of 157 ft., an extreme breadth of 60 ft., a moulded depth of 15 ft., and a draught of 10 ft. The displacement will be 710 tons, and the pull on the bollard is estimated at 15 tons. To ensure good steering and manoeuvring qualities, the rudders will have a large surface and will be actuated by electric-hydraulic steering gear, controlled from the wheelhouse by telemotor installations. Arrangements will be made for hand steering in emergencies. Deck machinery for each vessel will include a 16-h.p. electric windlass taking 1¾-in. diameter chain cables for the 12-cwt. anchors and fitted with warping drums on each side, and a 30-h.p. electric after-warping capstan of 24-in. diameter. Two "Monarch" shock-absorbing towing hooks, each tested to 50 tons, will be fitted to the after ends of the vessels' bridge decks.

The propelling machinery of each vessel will consist of four sets of Diesel-electric machinery, connected in series to two independent propulsion motors. The Diesel engines of each set will be supplied by Davey, Paxman and Company, Limited, Colchester, and the generators, which will give 339 kW at 305 volts and 1,600 r.p.m., together with the propulsion motors, exciters, control gear and ancillary equipment, will be constructed by the British Thomson-Houston Company, Limited, Rugby. Each of the motors will transmit up to 800 h.p. at 600 volts and 212 r.p.m. to the independent paddle-wheel shaft through Renold chain drives of about 8 to 1 reduction ratio. The paddle wheels will be of the feathering type with star centres arranged inboard on the paddle blocks. The vessels will have a free-running speed of 15 knots.

The last paddle tug to be constructed for naval service was the Pert, which was completed in 1916. In all, ten paddle tugs, ranging up to 56 years of age, are at present in use in H.M. Dockyards and the new vessels have been designed to replace the least serviceable of these.

* * *

## KEADBY-MONK FRYSTON LINE

We regret that in the description of the 275-kV Keadby-Monk Fryston line which appeared on page 54 of our issue of July 8 we omitted to state that the towers were designed and supplied by Blaw Knox Limited, 90 Brompton-road, London, S.W.3.

**The Bell X-2 supersonic aircraft, propelled by a Curtiss-Wright rocket motor, with a " power almost equal to that developed by a modern cruiser," is designed for speeds well up in the supersonic region where aerodynamic heating effects become important. The aircraft is seen here in gliding flight; powered trials will commence this year at Edwards Air Force Base, California.**

## THERMAL-BARRIER EXPERIMENTAL AIRCRAFT

### *The Bell X-2*

The United States Air Force in Washington last week disclosed that flight trials are expected to commence shortly on a rocket-powered supersonic search aircraft which is designed for speeds at which aerodynamic heating effects become appreciable. The new aircraft, the X-2, is designed and constructed by the Bell Aircraft Corporation, Niagara Falls, New York.

The Bell X-2 is shown in the accompanying illustration in gliding flight over Edwards Air Force Base, where the powered flights will be carried out. At the temperatures at which the X-2 is expected to fly the strength of aluminium alloys is inadequate for structural use, and therefore stainless steel and K-monel metal are largely employed in the wing and fuselage structure. For the same reason, the windscreen fitted on the X-2 is of highly-tempered glass capable of withstanding almost 1,000 deg. F., and is resistant to infra-red rays since, at the dust-free altitudes at which the X-2 will fly, the pilot could be seriously burned by the sun's rays.

Since a retractable wheeled undercarriage would occupy space required for fuel storage for the voracious rocket motor, the main undercarriage of the X-2 comprises a flat skid. The aircraft is propelled by a Curtiss-Wright rocket motor which is described as being " capable of developing power almost equal to that developed by a modern cruiser." To obtain the maximum duration of flight, the aircraft is carried to altitude by a B-50 bomber aircraft adapted for the purpose, from which it is then launched.

For the pilot's protection, the cabin is heavily insulated, pressurised, and can be jettisoned. If the pilot has to leave the X-2 at high altitudes, explosive charges would separate the entire cabin from the aircraft. A ribbon-type parachute would carry the cabin to a lower altitude from which the pilot could then parachute to the ground.

The X-2 is the fourth high-speed high-altitude research aircraft built by the Bell company. In 1947, the Bell X-1 made history by exceeding the speed of sound for the first time. In 1953, a development of this aircraft, the X-1A, reached a speed of more than 1,600 m.p.h. at an altitude of about 70,000 ft.—equivalent to a Mach number of about 2·5. Earlier, the Bell X-5 aircraft had demonstrated the feasibility of the variable-sweep-back wing.

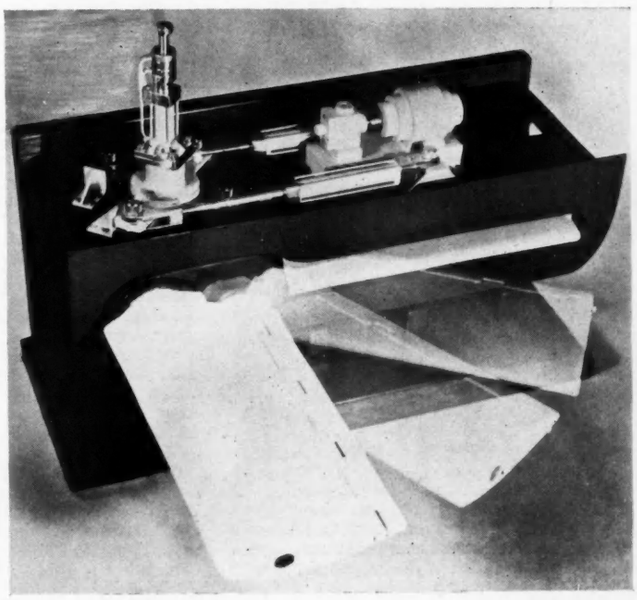
## FOLD-BACK FINS FOR SHIP STABILISER

### *Economy of Space*

Stabilisation of ships by means of fins which produce a righting moment as the ship rolls was first used to any extent during the Second World War. Certain destroyers and escort vessels were fitted with fin stabilisers, and after the war some cross-channel packets were so fitted, notably the " Maid of Orleans." The P. and O. passenger liner " Chusan " was the first large vessel to incorporate this equipment, which was in her case of the Denny-Brown type and was fully described in ENGINEERING for December 29, 1950 (vol. 170, page 557).

A system using fins to produce a righting moment is now being developed by the Marine Division of the Sperry Gyroscope Company, a division of Sperry Rand Corporation, Garden City, New York. The equipment is called the " Gyrofin," and a model of one of the fins is shown in the accompanying illustration. This shows the way in which the fin folds back into the ship's hull, the most striking feature of the Gyrofin. This construction means that the space occupied by the whole installation is considerably reduced. The fin itself is a standard symmetrical hydrofoil with a full-span flap, and is attached to a stub shaft which mounts on heavy roller bearings. These main tilt bearings, which transmit the stabilising force to the ship, are permanently assembled and sealed within a single steel casting, and are completely immersed in oil for positive lubrication. A rotary seal on the flange connection to the fin requires no extensive machined surfaces exposed to the corrosive effects of sea water. The entire assembly is pivoted vertically on roller bearings which permit the fin to fold back into the fin box, as the illustration shows.

The motion of the ship in response to wave action is measured by a rate-sensitive gyroscope and associated accelerometers. An electrical signal is produced that continuously represents a measure of the uncompensated force tending to roll the vessel. This signal is used to regulate hydraulic pumps to tilt the fins until their effort balances the wave effect. The stabilising effort of the fins is governed by the ship speed and the angle of attack of the water relative to the fins. This angle of attack is influenced by the vertical motions of the wave and of the ship, and the Gyrofin system compensates for these disturbing effects by use of a strain gauge in the fin mounting to measure the stabilising effort being applied to the vessel. This feature protects the fins against overload and ensures their operation for the greatest stabilising efficiency.



**The model shows how the fins fold back into the hull of the ship when they are not required. Strain gauges in the fins measure the stabilising effect applied to the vessel, affording a protection against overload.**

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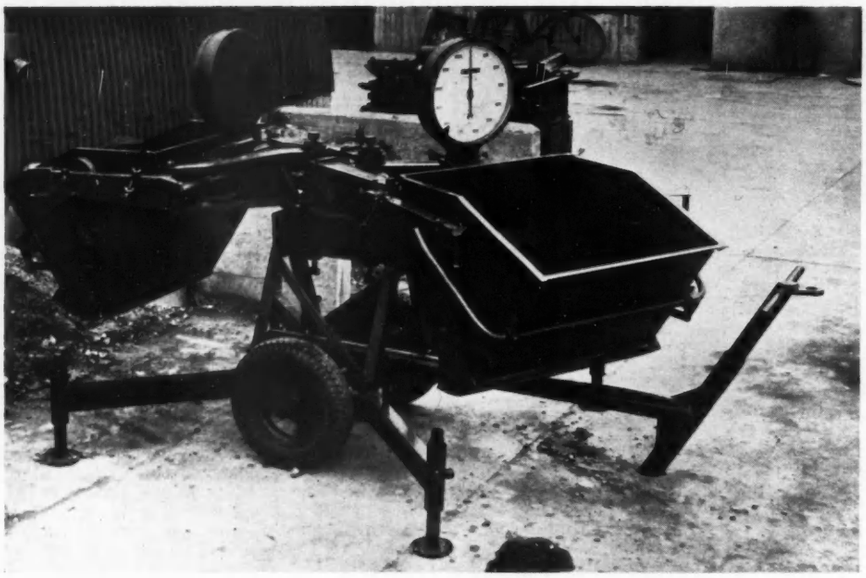
## PROTECTION IN INDUSTRY

Arrangements have been made by the British Occupational Hygiene Society to hold their autumn conference at the London School of Hygiene and Tropical Medicine, Keppel-street, London, W.C.1, on Friday, November 4, 1955, commencing at 11 a.m. The theme of this year's conference will be " The Use and Abuse of Protective Equipment."

Papers on the protection of the lungs will be read by Mr. T. Whittaker, Safety Department, Imperial Chemical Industries Limited, and Mr. A. C. Peacock, and on the protection of the skin by Dr. A. Lloyd Potter, Chemicals Division, I.C.I., and Professor J. R. Squire, University of Birmingham. There will also be papers on the protection of the eyes and feet.

Admission cards and further particulars may be obtained from the Society's honorary scientific secretary, Mr. D. Turner, Medical Research Laboratories, Holly-hill, London, N.W.3.



**The Winget swing weighbatcher has two independently mounted 10-cub. ft. skips. The skips are discharged by the operator pressing downwards on the levers.**

# THREE PIECES OF BUILDING PLANT

## HANDLING AND WEIGHING AGGREGATES AND DRESSING CONCRETE SLABS

Three new pieces of plant now being built by Winget, Limited, Rochester, Kent, are the swing weighbatcher, shown above, and the drag scraper, illustrated below, for handling concrete aggregates and the "Rotorfloat" (shown at the foot of column three) for obtaining a good finish on granolithic and concrete floors and pavements.

The swing weighbatcher has been designed to feed mixers with a concrete-batch capacity of up to 14 cub. ft. and can if required feed two mixers in tandem, working skip to skip. As may be seen from the illustration, it consists of two rotating skips, each with a weighing device, mounted on chassis with rubber-tyred wheels. The two skips are independently mounted, so permitting the loading of one skip at any position within an arc of 180 deg. while the other is being discharged into the mixer hopper. This arrangement allows easy loading from a widespread heap of aggregate and gives a short overall time cycle. The skips on the standard machine (as illustrated) have ample capacity for 10 cub. ft. loads, but detachable flare plates, supplied loose with every machine, will increase the skip capacity to 14 cub. ft. The large, easy-to-read dial gauges will record loads up to 1,440 lb. with an error of within plus or minus 0·5 per cent.

**The new drag scraper for concrete mixers is built into the machine and uses the mixer's motor. Simultaneous operation of the hopper and scraper is not possible.**

The discharge levers have been located for ease of operation and are moved downwards under the weight of the operator. Continued pressure on the handle, to hold the discharge door open, has the effect of swinging the skip bottom forward and further over the mixer hopper, so discharging the contents well towards the hopper throat. Easy swinging of the skips is assisted by the needle roller bearings fitted to the king posts, and all the bearings are lubricated using a grease gun.

Pneumatic wheels and a detachable towbar have been provided; locking screws are fitted to clamp the radius arms, so making the weighing devices "dead" and the machine as a whole well balanced during transport. There is, therefore, little likelihood of damage to the knife edges or other parts of the weighing mechanism while the machine is being towed. Under actual working conditions, as may be seen from the illustration, four screw jacks are fitted for "taking the weight" and for levelling up the machine.

Welded steel sections and steel plates are used throughout except for the radius arms which are Meehanite "A" castings. The dead-weight of the swing weighbatcher is just over 12 cwt.

The second piece of equipment, which is illustrated on the left is a mechanically operated drag scraper. Available for the company's 7NT and 14MT mixers, it is built into the mixer and is used for scraping ballast from stockpiles and depositing it in the hopper. The mixer's own motor is used for hoisting the scraper, but overloading of the motor is avoided by a cut-out device that ensures that the hopper does not operate at the same time as the scraper.

### POWER-OPERATED FLOAT

The third Winget machine to be described is, in effect, a power-operated rotary trowel or float, designed to give a good finish to concrete slabs or floors, particularly where a granolithic finish is used. The Rotorfloat is illustrated below.

Designed to do the work in a fraction of the time and cost of conventional hand methods, the machine will cover an area of up to 225 sq. yd. per hour, depending upon the skill of the operator. The incorporation of separate adjustable blades is claimed to give a machine having several advantages over the conventional single-disc float, namely: lightness, lower cost of blade replacement, and an ability to suit different finishes. Compared with the single-disc float, the new machine is said to be easier to operate, being less likely to "dig in" to the surface of the concrete, and the separate blades show a smaller tendency to the undesirable suction and adhesion that are characteristic of the full-area disc.

Weighing only 127 lb., the machine is easily moved about the site or transported from one site to another. The power unit is a 1½-h.p. four-stroke Villiers petrol engine or a JAP engine of similar size.

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## NEW SLOTTED ANGLE

### Positive Bolt Fixing

"Supaslot Major"—a slotted-angle material for the construction of racks, benches, trolleys, jigs and partitions, etc.—has been introduced by the Slotted Angle Company (G.B.), Limited, Broadway Chambers, 40 Broadway, London, S.W.1. It is made from cold-rolled mild steel in both 12 s.w.g. and 14 s.w.g. material and is made with flange widths of 2 $\frac{9}{16}$ in. and 1 $\frac{1}{16}$ in. Provision of slots at 45 deg. on both flanges permits four-bolt fixing at $\frac{3}{4}$-in. intervals where members are attached at right angles, and three- or four-bolt fixing of members at other angles. Circular holes in the slot pattern gives a positive location of members.

Accessories available for use with the angles are 20-s.w.g. steel panels, including one 36 in. long by 6 in., various sizes of castors and hinges, and a simple single-stroke cutter. The angle is normally available in bundles of ten 10-ft. lengths with 100 nuts and bolts. The standard finish is in polychromatic grey stoved over a rust-proofing aluminium etching primer.

**The Rotorfloat will dress up to 225 square yards of concrete floor per hour. The use of three separate blades are claimed to give advantage over the single-disc float.**

# ATOMIC ENERGY

## A GLOSSARY

To serve as a guide to the articles appearing in this and subsequent issues on the proceedings at the International Conference on the Peaceful Uses of Atomic Energy, the following glossary has been compiled. In every case an attempt has been made to convey the meaning rather than provide a rigorous scientific definition.

*Alpha Particle.*—A positively-charged particle emitted in the radioactive decay of some heavy nuclei, for example, uranium and radium; identical with the helium nucleus and composed of two protons and two neutrons; it has a positive electrical charge of two. It is one of three kinds of radioactive emission (see beta particles and gamma radiation).

*Atom*; *Atomic Structure.*—The atom consists of a massive central nucleus carrying a positive electric charge, around which electrons move in orbits at relatively great distances from it. According to present theory the nucleus is made up of protons and neutrons. The number of protons is called the atomic number of the element and determines the charge on the nucleus—and hence its chemical properties. The sum of the number of protons and neutrons is called the mass number and determines the mass of the nucleus. The number of neutrons in an atom of a given element can vary, resulting in nuclei that have the same atomic number but different mass numbers; these variants are called isotopes of the element. The number of electrons in a neutral atom is equal to the number of protons in the nucleus, and their charges balance the equal and opposite charge of the nucleus.

*Beta Particle.*—An electron, either negatively or positively charged, emitted during certain types of radioactive disintegration; generally of high speed.

*Breeder Reactor.*—Generally a nuclear reactor which produces more fissile atoms than it burns. The term is sometimes confined to a nuclear reactor which produces the same kind of fissile material as it burns, without specifying whether or not there is a net gain of fissile material.

*Chain Reaction* (*Nuclear*).—When a fissile nucleus captures a neutron and fission occurs several fresh neutrons are released; these in turn cause fission in other fissile atoms which release yet more neutrons to cause further fissions; this is a chain reaction.

*Control Rod.*—A rod of neutron-absorbing material used to control the operation of a nuclear reactor.

*Coolant.*—Any cooling agent; specifically a liquid or gas which is circulated through or about the core of a reactor to maintain a low temperature.

*Core.*—In a reactor, the active mass in which fission takes place.

*Cosmic Radiation.*—Very penetrating ionising radiation which reaches the earth from outer space.

*Curie.*—The unit of radioactivity now defined as the quantity of radioactive isotope which decays at the rate of $3{\cdot}7 \times 10^{10}$ disintegrations a second; approximately equal to the activity of one gramme of radium.

*Cyclotron.*—A machine that accelerates heavy particles to very high speeds in a spiral path. The particles are held in the spiral by a magnetic field and are accelerated twice in each revolution by an electrostatic field, produced by a radio-frequency oscillator.

*Deuterium.*—The isotope of hydrogen of mass 2; often called heavy hydrogen. Natural hydrogen is a mixture of three isotopes: protium, deuterium and tritium.

*Deuteron.*—The nucleus of the deuterium atom.

*Disintegration.*—The spontaneous change of the atoms of a radioactive element into somewhat lighter atoms with the emission of alpha or beta particles or gamma rays.

*Electrometer.*—An instrument for measuring very small electric charges.

*Electrons.*—The smallest particle forming a constituent of the atom; carries the elementary negative charge of electricity. It has a positively charged counterpart of equal mass called the positron.

*Electron Volt.*—A measure of the energy of a particle. A particle carrying a charge equal to that of the electron, which when accelerated by a potential drop of 1 volt acquires a kinetic energy of 1 electron volt (eV).

*Fast Reactor.*—A nuclear reactor in which most fissions are caused by neutrons moving with the high speeds they possess at the time of their birth in fission.

*Fertile Material.*—Isotopes capable of being readily transformed into fissile material by the absorption of neutrons, particularly uranium 238 and thorium 232; sometimes called source material.

*Fissile Material.*—Isotopes in which neutron-induced fission can take place, that is uranium 233, uranium 235 and plutonium 239. Called fissionable material in America.

*Fission.*—The splitting of an atom into two or more approximately equal fragments (the fission products). Fission is accompanied by the emission of neutrons and the release of energy. For practical use fission induced by neutrons is the most important, but fission can be induced by heavy particles or gamma rays, and can occur spontaneously.

*Gamma Radiation.*—Electromagnetic radiation similar to X-rays, emitted by atomic nuclei, generally in radioactive decay.

*Gaseous Diffusion.*—A method for separating isotopes, for example those of uranium, by causing a gaseous compound to diffuse through a porous membrane; the lighter molecules diffuse faster than the heavy ones and consequently their concentration increases on passing through the membrane.

*Geiger Counter* (*or Geiger-Müller Counter*).—A device for counting photons or charged particles by means of the ionisation they produce in a gas.

*Half-life.*—The time taken for the activity of a radioactive substance to decay to half its original value, that is for half the atoms present to disintegrate. Half-lives may vary from less than a millionth of a second to millions of years, according to the isotope.

*Heavy Water.*—Water consisting of molecules in which the hydrogen is replaced by deuterium.

*Infra-Red.*—Electromagnetic waves of wavelength longer than the longest visible light waves; infra-red radiation is heat radiation.

*Ion.*—A charged atom or molecule, that is one which has lost or gained one or more electrons. Ions can exist in gaseous form and in solution.

*Ion Exchange.*—A process in which ions from two different molecules exchange partners.

*Ionisation Chamber.*—A device for measuring the amount of ionising radiation. The radiation ionises gas in the chamber and the ions are collected and measured.

*Isotopes.*—Different atomic forms of same element. See Atom.

*Linear Accelerator.*—A machine in which particles are accelerated to high speeds in passing down a straight evacuated tube or waveguide. Acceleration is produced by electromagnetic waves in the tube.

*Mass Number.*—See Atom.

*Meson.*—Unstable particles with masses intermediate between those of the electron and the proton, found in cosmic radiation.

*Moderator.*—The material in a reactor used to reduce the speed of fast neutrons, as far as possible without capturing them.

*Multiplication Factor.*—A measure of the reactivity of a nuclear reactor; defined as the ratio of the number of neutrons in any one generation to the number in the immediately preceding generation (*k*).

*Neutron.*—Elementary particle having about the same size and mass as the proton but without electrical charge.

*Nuclear Reactor.*—A structure in which a fission chain reaction can be maintained and controlled. It serves in effect as a furnace and is usually composed of a core, a moderator, control rods, coolant and shielding.

*Nucleus.*—See Atom.

*Photo-Disintegration.*—The disintegration of a nucleus by gamma rays.

*Photo-fission.*—Nuclear fission induced by gamma rays.

*Photon.*—A quantum of electromagnetic radiation, that is the discrete unit of radiation.

*Pile.*—Nuclear pile is an older term for nuclear reactor; there is a tendency to keep this word for a reactor using natural uranium and graphite.

*Plutonium.*—The element, atomic number 94, produced by neutron irradiation of uranium-238. The isotope plutonium 239 is an important fissile material.

*Proton.*—The nucleus of the hydrogen atom. It carries unit positive charge and has unit mass.

*Quantum.*—See Photon.

*Radioactivity: Radioactive Decay.*—The property possesssed by some atoms of disintegrating spontaneously with the emission of a charged particle and usually gamma radiation.

*Radiography.*—A method of examining solid objects by passing X- or gamma radiation through them and photographing (or examining on a fluorescent screen) the shadows cast.

*Radioisotopes.*—Unstable and radioactive isotopes.

*Reproduction Constant.*—See Multiplication Factor.

*Scintillation Counter.*—An instrument for detecting charged particles by the flashes of light they produce in certain materials

*Shielding.*—Screen for protecting personnel from radiation. Rubber gloves are sufficient for alpha particles; lead aprons for beta or X-rays; but for gamma rays and neutrons from a reactor some seven feet of concrete are normally used.

*Shut-off Rod* (*Safety Rod*).—A neutron-absorbing rod which, in an emergency, can very quickly be inserted to shut down a nuclear reactor.

*Solvent Extraction.*—A method of separating one or more substances from a mixture by treating a solution of the mixture with a solvent that will dissolve the required substances and leave the others.

*Specific Activity.*—The radioactivity of unit mass of a radioactive substance.

*Synchrotron.*—A machine for accelerating electrons to high speeds; the electrons are kept in a circular path by a guiding magnetic field and are accelerated in this path by synchronous electric impulses. A machine called a proton-synchrotron has been developed on the same principle to accelerate protons.

*Thermal Reactor.*—A nuclear reactor in which the neutrons are slowed down to low speeds before causing fission.

*Thorium.*—The element of atomic number 90, a heavy metal; the isotope thorium 232 is a fertile material.

*Tracer.*—A small quantity of radioactive isotope used to follow the behaviour of larger quantities of inactive isotopes in biological, chemical or other processes.

*Tritium.*—The isotope of hydrogen of mass 3.

*Triton.*—The nucleus of tritium.

*Uranium.*—The element of atomic number 92, a heavy metal. Uranium 235 is the only naturally occurring fissile element; uranium 238 is a fertile material; uranium 233 is a fissile material that can be produced by the neutron irradiation of thorium 232.

*Uranium Hexafluoride.*—A gaseous compound of uranium with fluorine used in the gaseous diffusion process for separating the uranium isotopes.

*Van de Graaff Electrostatic Generator.*—An electrostatic generator in which a high potential is produced by the accumulation of electric charge conveyed to an insulated conductor by a continuously moving belt. The potential generated is used for accelerating charged particles.

## *Labour Notes*

# EXCESSIVE WORKING HOURS

Three resolutions carried unanimously at the conference of the Confederation of Shipbuilding and Engineering Unions last Thursday were for an immediate demand for a 40-hour week, a campaign against systematic overtime work, and a limit of 20 hours overtime a month (at present fixed at 30 hours). Indirectly these demands appear to have been prompted by the fear that the growth of "automation" will gradually reduce the numbers employed in the engineering and shipbuilding industries unless hours are reduced without delay. A similar reaction was observed among United States workers earlier this year. At the same time it is an endeavour to secure for shop labour a share of the benefits to be derived from increased mechanisation.

Mr. W. J. Carron of the A.E.U., who proposed the demand for the 40-hour week, pointed out that several of the more progressive British companies had already introduced it without loss of production, and that output per man had nearly doubled since the working week was reduced from 47 to 44 hours. Mr. F. Foulkes, president of the Electrical Trades Union, introduced the resolution for the campaign against "constant and excessive overtime," on the ground that the average of 49 hours worked by members of the engineering unions was injurious to health, interfered with their leisure activities and encouraged the employers to quote high figures of average earnings when increases were sought in basic wages. It was, in his view, worth putting up with a temporary lowering of living standards rather than carry on as at present.

These demands for shorter working hours (and for a third week of paid holiday) are likely to be hotly resisted by the employer, on the ground that mechanisation cannot be increased overnight and that in the interim output must fall. In the short term, any fall in engineering exports or even the failure to raise them, is much more likely to interfere with the living standards of engineering workers than a reduction in the number of hours worked.

### WAGES ON THE RISE

Claims for increased wages have been high on the agenda of practically every union conference held this summer, and developments last week suggest that the entire country's labour force will have its wages brought into line with those 10·4 million workers who have been granted increases in the first half of the year. The decision of the Confederation of Shipbuilding and Engineering Unions last Wednesday to press for "a substantial increase" on behalf of its 3 million members was widely expected. Details of the claim are to be settled at an executive meeting this week, but demands for a 10 per cent. increase for skilled workers—about 15*s.* a week—and a somewhat lower increase for labourers are expected to be submitted to the employers in the autumn.

The projected increase in the differentials between skilled and unskilled was unsuccessfully opposed by the representatives of the T.G.W.U., who argued that the lower paid workers should not be penalised by the craftsmen's desire to improve their own conditions and suggested that differentials should be fixed only after a comprehensive survey of the wage structure in the engineering industries. The A.E.U., who moved the motion for the wage claim, justified it on the ground that the workers had a right to a fair and balanced share of the greater prosperity which they helped to bring about and that, in any case, wage advances in the past might well have contributed to the prosperity of the employers by forcing them to modernise and to improve their efficiency.

The N.U.R. executive are to invite other railway unions to consider a joint wage claim, probably also of about 10 per cent. The Amalgamated Woodworkers, the National Federation of Building Trades Operatives, the N.U.M., and several other unions are pressing in the same direction. The rise in productivity will have to be very substantial indeed if British products are not to be priced out of overseas markets.

### GERMAN WORKERS SPOIL FOR A FIGHT

There are signs that workers in Germany are prepared to fight for higher pay and a shorter working week. The Western German Mineworkers' Union decided last week to change its rules to enable its executive to call a strike without first holding a ballot of its members in cases of "attacks on the existence of the trade unions or on the democratic basic order of the State." The 9 per cent. wage increase secured by the mineworkers in April restored their position as the best-paid workers in Germany and they are now pressing for a reduction of the working week. They want a five-day week with a working day of 7½ hours—37½ hours compared to the average week of 47 hours they have been working since the war. The employers have said they are unwilling to grant shorter hours as well as higher wages and are likely to offer determined opposition to the claim.

Other unions, including the vehicle workers, have made similar claims and there are signs that the pressure on wage rates will lead to an all-round increase. Unemployment is at its lowest since the war, having dropped to 566,926 at the end of July compared with 934,400 a year previously. Already German employers are seeking foreign labour, and an agreement between the West German and Italian Governments is said to have been signed recently providing for the hiring of 50,000 Italians for seasonal work in 1956. Despite this, the rate of expansion of German manufacturing industry is such that an acute labour shortage next year will be hard to avoid. In its train are likely to come demands for wage increases and shorter working hours from a labour force that is one of the longest worked and lowest paid in Western Europe.

### UNEMPLOYMENT

The number of registered unemployed at July 11 was the lowest since the war. The only regions where the percentage of unemployment was more than 1·0 of the total number of employees were Scotland (2·1), Wales (1·4) and North Western and Northern (both 1·3). The total number of people in civil employment at the end of June was 22·3 million, 286,000 more than a year ago. The rapid decline in the numbers employed in the cotton industry was mainly responsible for the fall of 11,000 during July in the numbers employed in manufacturing industry although the total at the end of June was 246,000 higher than at June, 1954. Over 85 per cent. of this increase was accounted for by the metal and engineering industries.

In the Midlands, where the shortage of workers is most acute (unemployment was 0·4 per cent.) the number of vacancies is estimated at over 56,000. Little wonder, therefore, that employers of a number of large companies have been recruiting labour in Italy. Already there are about 3,000 Italian workers, a fifth of them in the mines. The rayon industry in particular has obtained workers from its Italian subsidiaries for shift work unattractive to British labour. Already there are some 33,000 foreign workers (mostly Poles, coloured people and European volunteers) in the area and more are expected during the next few months. Only a large nationally-organised scheme, however, could possibly fill the gap and so far at any rate nothing has been heard of a move in this direction.

### LAY-OFF FUNDS FOR UNITED STATES WORKERS

Recent developments on the American labour front have been mainly towards ensuring greater security for wage earners. First, pension schemes, and now "lay-off" funds. The United Automobile Workers, under the leadership of Walter Reuther, have concluded agreements with the Ford Motor Company and General Motors which guarantee that workers laid off by the company have their State unemployment benefit increased to the average level of their earnings for a maximum of 26 weeks in the year provided they have been on their company's books for three years. This was designed to counter the motor companies' tendency to lay-off workers seasonally. It had long been a complaint of the U.A.W. that although rates of pay in the industry were high, average earnings were relatively low.

American employers have reacted violently against the extension of lay-off funds to other industries. The director of the Southern Coal Producers' Association has called for a "multi-million dollar fund" to fight against it. Despite this and other opposition the lay-off fund demands are likely to spread. Already the U.A.W. are preparing to extend it to the agricultural machinery industry, though the manufacturers may fight the Union. They, in common with many other American industries, are subject to wider market fluctuations than vehicle manufacturers and are afraid they will not be able to bear the cost of the scheme.

There is, however, some opposition among the workers themselves, many of whom argue that "we want cash now, the future can take care of itself." Nonetheless the momentum behind the union's demand for greater security is a strong one and it is doubtful if employers will be able to resist it.

### SHORTAGE IN THE OFFICE

An announcement last week by the Treasury of a plan to recruit men and women over 40 years of age for certain pensionable clerical posts in the Home Civil Service is yet further evidence of the acute shortage of clerical workers. The Treasury point out that the plan fits in with the Government policy on the employment of older people, and that it takes into account not only the changing age distribution of the population but also "the need to make the fullest use of the country's manpower in conditions of full employment." The truth of it is that Government departments, local government offices, the banks, insurance companies and even manufacturing industry are finding it almost impossible to recruit office workers.

The problem was analysed and discussed at length in a leading article in *The Times* of August 12. Briefly, the argument ran thus: the country is in a state of inflation and over-employment and the shortage of labour is general. Clerical wages have risen far less than manual wages in the past two decades, particularly since the war. But it is doubtful if even the filling of the 10 to 20 per cent. gap between clerical and manual earnings would solve the problem unless young men were given the same opportunity to support themselves pushing a pen as they have working a machine. Boys and girls mature more quickly than they did and want to secure their financial independence early. To raise clerical wages to the necessary level would be too costly to consider and would considerably hasten the process of office mechanisation. Socially, clerical jobs are no longer the asset they were when real command of the "Three Rs" still belonged to a minority, and the way to the top via the office boy's job is no longer the accepted way. Also the brighter boys and girls tend to go to university first.

There are other aspects of the problem: the gradual mechanisation of the office takes away much of the security appeal; the glamour of the white collar has passed to the newer industries, such as atomic energy and aircraft, and the possibility of raising one's earnings by extra effort (piecework) is not normally present. None the less, a solution to the problem must be found. In part it lies in raising wages, particularly those of the young, in part by increasing mechanisation and efficiency. There is much to suggest that productivity could be raised enough to eradicate the shortage.